



SIERRA LEONE

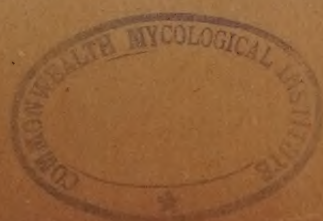
Rice Cultivation

Report on a Visit to Ceylon and
South India, with Proposals
for Sierra Leone.

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CONTENTS.

	PAGE
I—INTRODUCTION	1
II—RICE	1
<i>A</i> —MADRAS	1
EXISTING METHODS OF CULTIVATION AND THEIR POSSIBLE APPLICATION IN SIERRA LEONE	1
(i) Normal Wet-land Cultivation	1
(ii) Wet-land Farm and Nursery Management	3
(iii) Upland Rice	5
(iv) Rice Cultivation in Saline Lands	5
(v) Rice Cultivation in Deep-water Areas	5
WORK OF MADRAS DEPARTMENT OF AGRICULTURE TO IMPROVE RICE CULTIVATION	6
RICE MILLS	7
<i>B</i> —CEYLON	8
INDIGENOUS METHODS	8
WORK OF THE AGRICULTURAL DEPARTMENT	8
SUGGESTIONS FOR AN IMMEDIATE PROGRAMME OF WORK IN SIERRA LEONE RICE AREAS	9
SUGGESTED PROGRAMME FOR EXTENSION WORK IN SIERRA LEONE	12
PROSPECTS FOR RICE MILLS IN SIERRA LEONE	13
III—GENERAL AGRICULTURE	14
AGRICULTURAL SYSTEMS	14
CEYLON	14
MADRAS	14
SIERRA LEONE	14
PERENNIAL CROPS	15
Cacao	15
Coffee	15
Coconut	16
Cashew	16
Casuarina	17
Jak	17
Pepper	17
ANNUAL CROPS	19
Millets	19
Benniseed	19
Sunn-hemp	19
CATTLE	19
TILLAGE	19
South India	20
Sierra Leone	21
IRRIGATION	22
IRRIGATION SYSTEMS	23
APPLICATION OF IRRIGATION WATER	23
WATER-LIFTS	24
PROSPECTS FOR IRRIGATION IN SIERRA LEONE	25
IV—SUMMARY	26
V—APPENDIXES	
I. ITINERARY	28
II. RICE CULTIVATION IN SALINE LANDS	30
III. TECHNIQUE OF PURE LINE SELECTIONS	34
IV. LISTS OF SEEDS AND PLANTS OBTAINED IN CEYLON AND INDIA	38

RICE CULTIVATION.

Report on a Visit to Ceylon and South India, with Proposals for Sierra Leone.

I—INTRODUCTION.

The chief object of my visit was the study of rice cultivation and I was directed to pay particular attention to the breeding work being done in connection with this crop by the Madras and Ceylon Departments of Agriculture.

2. Rice is the main subject of this report, but I also refer to other matters which can be usefully considered in connection with agricultural development in Sierra Leone. I do not attempt to describe agricultural methods and conditions, or the various agricultural stations and institutions visited, unless such information is relevant. Unless stated to the contrary, "rice" refers to wet-land rice.

3. My itinerary is given in Appendix I. Before I left England Mr. H. C. Sampson gave me very useful advice with regard to my itinerary as well as much valuable information of a general nature. In Ceylon the details of my itinerary were decided in consultation with the Director of Agriculture and the Economic Botanist, and in Madras the Paddy Specialist, Mr. K. Ramiah, helped me to make the best use of my time.

4. Both in India and Ceylon I was almost invariably accompanied on trek by the Agricultural Officer of the Division or Circle being visited, and on no occasion was I without the company of some officer intimately familiar with the area. I visited as many as possible of the Government Agricultural Stations but I did not overlook the importance of making myself familiar with the practices of the ordinary farmer, and wherever I went a local agricultural officer accompanied me on a round of typical agricultural holdings.

II—RICE.

A—MADRAS.

5. *Introduction.*—In Madras the conditions under which rice is grown vary very widely and in many cases have no parallel in Sierra Leone. In some areas, however, one finds a striking similarity of conditions of soil, climate and even of topographical features. When comparing rice cultivation in the two countries it is necessary to keep in mind that, whereas in Sierra Leone the cultivation of this crop is of comparatively recent origin, in Madras it has been practised for countless generations and the farmer has attained a high degree of skill and understands and practises water control, manuring, and thorough cultivation; for this reason the Department of Agriculture in Madras has a very sound basis for its research and extension work. In Sierra Leone, however, the farmer's methods are comparatively haphazard and wasteful; and therefore one of our first duties is to improve his methods of cultivation, for although at the moment he in many cases obtains yields as good as those of the Indian ryot yet for this happy result he is more indebted to the great fertility of the land than to his skilful management of it. If swamp lands in Sierra Leone are to be continually cultivated without suffering deterioration the farmer must sooner or later take steps to guard his land from loss of fertility which will surely take place if he does not adopt methods which will prevent soil erosion, alkalinity, and depletion of organic matter, the remedies for which are respectively water control, drainage and manuring.

EXISTING METHODS OF CULTIVATION AND THEIR POSSIBLE APPLICATION IN SIERRA LEONE.

(i) *Normal Wet-land Areas.*

6. *East Coast.*—In the deltas of the East Coast the annual rainfall is only 40 inches and rice cultivation would not be possible on a large scale were it not for the very elaborate irrigation systems which distribute the waters of the Cauvery, Kistna and Godavari rivers. The methods of cultivation are of great interest but climatic conditions have no parallel in Sierra Leone.

7. *Central Madras*.—Here too the direct rainfall is inadequate, being only 27 inches at Coimbatore, and the farmer relies to a great extent on water raised from wells although some areas have tanks (reservoirs) which are filled by streams rising in the Western Ghats; conditions are dissimilar to any in Sierra Leone.

8. *West Coast*.—Climatically and topographically the Malabar and South Kanara Districts are very like Sierra Leone. Mr. Sampson noticed this when he visited Sierra Leone and in Kew Bulletin No. 6 of 1930 he gives a short account of agriculture in South Kanara and expresses his belief that it has evolved from a type of agriculture similar to that found in Sierra Leone at the present day. As a corollary it is not unlikely that agriculture in Sierra Leone will develop along similar lines; and for this reason it was recommended that I should visit the West Coast of Madras to study conditions there. Since my visit I feel that we can profitably attempt to copy the methods of the Kanaresa ryot, as such a course if successful would lead to the fullest development of the swamp and valley lands; a great increase in the area under wet-land rice, garden crops and fruit trees, and a diminishment of the area devoted to shifting cultivation. The Kanara and Malabar Districts lie between the Western Ghats and the sea; and, excluding the Ghats, most of the area consists of low lateritic plains with red ferruginous soils. There is rather less gravel than in Sierra Leone but on the whole the soils are very similar. In temperature, humidity and rainfall there is also a resemblance as a study of the following table will prove:—

				Njala (1930).				Pattambi (1929).			
				Max. Temp.	Min. Temp.	Relative Humidity.	Rain-fall.	Max. Temp.	Min. Temp.	Relative Humidity.	Rain-fall.
January	...	...	...	90.29	68.45	75.35	—	93.9	69.8	65.6	—
February	...	...	...	94.28	69.32	68.65	.45	95.4	72.4	73.0	1.73
March	...	...	...	94.87	69.97	61.87	.62	98.0	75.0	72.0	1.84
April	...	...	...	94.93	71.17	63.72	3.34	93.8	75.5	80.6	4.73
May	...	...	...	90.84	72.35	79.44	15.22	92.7	78.0	82.6	1.97
June	...	...	...	88.67	70.90	78.88	16.60	84.1	73.9	90.1	32.89
July	...	...	...	84.74	70.97	87.94	14.67	82.5	73.9	91.6	39.82
August	...	...	...	83.26	70.71	90.69	30.31	83.8	73.6	91.5	14.83
September	...	...	...	85.57	71.90	90.30	22.92	86.6	74.2	89.0	4.49
October	...	...	...	88.90	71.06	83.27	9.40	86.9	73.4	90.3	16.89
November	...	...	...	91.87	71.73	82.23	10.39	90.2	73.4	81.0	3.53
December	...	...	...	91.48	71.10	80.87	4.15	92.7	72.0	73.4	.14
Total	...	...	...	...	...	...	128.07	...	...	...	122.86

Pattambi, the Agricultural Research Station for the West Coast, is in Malabar. The rainfall in South Kanara is slightly heavier and probably averages 140 inches; the bulk of the rain is precipitated, from June to August, during the South-west monsoon but there is also quite a heavy fall in October during the time of the North-east monsoon. The spell of comparatively dry weather between the two monsoons facilitates the harvesting of the first rice crop.

9. Both upland and wet-land rice are grown but the area devoted to the former is comparatively small. The bottoms and lower slopes of the valleys are used for wet-land rice cultivation. There are no elaborate irrigation systems nor are any necessary as there is ample direct rainfall; in the dry season, however, an additional crop may be grown in the lowest fields in the valleys by utilising water from wells and streams. The wet-land areas may be divided into three classes according to the number of crops they can produce in a year; thus there are single, double and treble-crop lands. The single-crop lands are found on the lower slopes of the valleys while the double and treble crop areas lie in the valley bottoms and are comparable to the valley swamp lands in which the Sierra Leone farmer grows his rice. All wet lands are bunded and levelled; and irrigation of the main and second crops is effected by impounding the direct rainfall, augmented by surface flood water and seepage from the higher lands.

10. *The single-crop lands* lie in terraces along the lower slopes, and the individual fields are usually narrow and so laid out that the bunds follow the contour lines; there is frequently a big difference between the levels of adjoining fields. The soil is often shallow and unretentive of moisture and consequently it is only possible to raise one crop which may be either transplanted or sown in puddle. If transplanted, the seedlings are raised in dry nurseries sown in April or May. The farms are liberally manured with farm yard manure and leaves.

11. *The double-crop lands* are found in the valley bottoms and in the low-lying areas of the coastal plain. The fields are larger, the difference in level less, and the soil heavier and more retentive of moisture than is the case in single-crop lands. In some cases the land is ploughed during the dry weather but it is more usual to plough wet after the break of the South-west monsoon. The fields are manured as in the single-crop lands. Seed is sometimes sown broadcast but transplanting is more usual, seedlings being raised in dry nurseries. Harvesting of the first crop commences at the end of September, after which the stubble is turned in by ploughing two or three times; the fields are usually flooded to some extent at this time. The seedlings for the second crop are also raised in dry nurseries which are shown in August; the crop is harvested in January. The second crop occasionally needs irrigation during the later stages of growth.

12. *Treble-crop lands* are really double-crop lands favourably situated in the valley bottoms so that irrigation is possible in the dry season. The water supply is usually raised by means of a 'picottah' from wells and river beds, but in valleys where perennial streams occur the water is sometimes banked up by temporary dams and diverted into the marginal fields. The growing of rice as the third crop cannot be considered an economic proposition as the labour involved is out of all proportion to the value of the crop. As a general rule rice is the only crop grown in wet lands although in treble-crop lands it is not unusual to raise, in addition, crops of tobacco, banana and vegetables.

(ii) *Wet-land Farm and Nursery Management.*

13. The following particulars refer to some aspects of rice cultivation as practised by the ordinary ryot. Particulars of the methods employed on the Government Stations will be found in Appendix II.

14. *Nurseries.*—Transplanting is general and the Indian appears to realise that the ultimate yield depends to an appreciable degree on the care bestowed on the nursery. In Sierra Leone the transplanting method is a comparatively recent introduction and many farmers do not do all they might to produce strong healthy seedlings: the use of mixed and poor seed, too high a seed rate, and the use of poor soil are all common failings. In India three types of nursery are used: dry, wet and intermediate.

15. *Dry Nurseries.*—In this type of nursery (which is the only kind found in Sierra Leone) direct rainfall forms the sole water supply and there is no controlled irrigation, although, if it can be arranged, the nursery is flooded at transplanting time to facilitate lifting. Dry nurseries are very commonly used on the West Coast where there is an ample rainfall. Seedlings raised in a dry nursery tend to accommodate their rate of growth to the rainfall and this is a decided advantage, because if weather conditions are not favourable for transplanting the seedlings may be left in the nursery for some time without suffering harm. If wet nurseries are employed the rice seedlings mature more rapidly and independently of weather conditions and great care is necessary to ensure that they are planted at the right time.

16. *Wet Nurseries.*—In the dry zone, where the crop is grown under controlled irrigation, wet nurseries are the rule. In this type of nursery the germinated seed is sown broadcast in puddle, the seed bed being flooded to a depth of two inches at the time.

17. *Intermediate Nurseries.*—In the Tanjore delta, as well as in other districts where the rainfall is not sufficient to make dry nurseries possible, an intermediate type of nursery, which may be termed semi-dry, is often made. This nursery combines some of the advantages of the two other types. The germinated seed is sown in puddle, the beds being flooded at the time, but the water is drained off after sowing and subsequently irrigated only if the surface soil shows signs of cracking.

18. *Preparation of Nursery.*—The seed bed is thoroughly cultivated and manured before sowing. In making a dry nursery the bed is repeatedly ploughed until a fine tilth is obtained; it is then manured with ashes and village refuse and again ploughed. In the case of the wet nursery, village refuse and farm-yard manure may be given but it is more usual to apply green leaves—at the rate of about 10,000 lb. per acre—after the land has been flooded and well puddled by ploughing. After two or three weeks the land is again ploughed, and levelled with the levelling board. In the semi-dry nursery the land is cultivated and manured while in a dry condition, but water is admitted immediately previous to sowing to permit of puddling and levelling.

19. *Seed Rate.*—The seed rate varies in different districts but the normal rate appears to be about 700 lb. per acre of seed bed. The quantity of seed considered necessary to supply sufficient seedlings to plant one acre of farm varies between 70 and 140 lb. The Agricultural Department recommends a lower seed rate and more economical planting

and considers 250–300 lb. to be sufficient for one acre of seed bed; and if the seed bed is well manured the seedlings will be strong enough for single planting and should be sufficient for a ten-acre farm.

20. *Farms—Tillage.*—On the West Coast it is usual to plough wet after the monsoon begins but in districts provided with channel irrigation ploughing commences as soon as water is available—which is often several weeks before there is any local rainfall. In some of the low-lying coastal areas of the West Coast, where sudden flooding is experienced, the lands are ploughed as many as five to six times in the dry season; this leaves the land in a very rough condition and it is necessary to break down the clods with wooden mallets.

21. *Manuring.*—As crops are grown on the same land every year, manuring is a necessity and is practised generally. The chief manurial needs of wet-land rice are nitrogen and phosphoric acid. The crop readily responds to applications of bulky organic manures which decompose under anaerobic conditions to give humus and wherever such manures are available they are used by the ryot; thus on the West Coast the higher lands are reserved for scrub and forest which provide leaves which may be applied direct to the farms which have been previously puddled or used first for bedding down the cattle and subsequently applied as farm-yard manure. In the dry central part of the Madras Presidency *Calotropis* is plentiful in waste lands and provides a valuable green manure.

22. In areas where green leaves are difficult to obtain as is the case in the Eastern deltas, the farmer is obliged to rely on farm-yard manure and village refuse, although latterly he has been using artificial fertilizers with profit. In these areas the Agricultural Department is advocating the growing of green manure crops and many farmers now do this. According to its nature, the green manure crop may be either ploughed in as it stands or it may be cut and trampled into puddle, being used not only for the land on which it is grown but also for other fields on which no manure crop has been raised. Experiments appear to show that green manures give best results when puddled in shortly (not more than three weeks) before the rice crop is planted, and it has been shown that if green manure is applied under aerobic conditions—ploughed in before irrigation—then large quantities of nitrates in addition to ammonium are formed; and on subsequent irrigation the nitrates are washed out, reduced to nitrites or lost as free nitrogen.

23. The best of the green manure crops are wild indigo, daincha, sunn-hemp, and field gram.

Wild Indigo (Tephrosia purpurea), is a small woody plant that attains a height of about thirty inches. Its advantages as a green manure crop are that (1) it is not eaten by stock; (2) once properly established it regenerates itself from year to year; (3) it does not grow too woody. Wild indigo is used on the West Coast as well as in the drier zones, and the following description is of the method used in the Kanara District to establish this crop. After the rice crop has been harvested in September or October the land is ploughed and indigo seed is sown with horse gram which crop frequently follows rice. As indigo seed has a hard testa it is advisable either to soak the seed before sowing or else to reduce the thickness of the testa by pounding the seed in a mortar containing sand. When the horse gram is harvested in January the indigo, then about six inches high, is left standing in the field. In June when the cultivation of the rice fields begins the indigo, which is then one to two feet in height, is ploughed in. This procedure refers to single-crop rice lands; in the moister double-crop lands the indigo is not sown until February. It is said that it is necessary to re-sow seed for two or three seasons before the crop becomes thoroughly established and capable of satisfactory self-propagation, although personally I should imagine that a sufficiently heavy initial sowing would obviate the necessity for re-sowing. Once established, indigo makes a good show each dry season; it does not come up in the rice crop, as apparently the seed lies dormant during the rainy season when the soil is water-logged.

Sunn-hemp (Crotalaria juncea), is an excellent green crop in addition to being a useful source of fibre and fodder. It is particularly popular in the deltas of the East Coast where it is sown broadcast in the rice crop at the end of the last irrigation for that crop; a few irrigations during growth are beneficial but are not always given in practice.

Daincha (Sesbania aculeata).—Another excellent green manure crop, one acre of which will, under favourable conditions, provide sufficient manure for four acres.

Field Gram (Phaseolus trilobus).—This is another popular green manure crop in the delta lands of the East Coast. It is also useful as a fodder crop and may be cut three or four times before it is eventually ploughed in as a green manure. Up to 20,000 lb. green leaf per acre has been recorded. The seed is sown after the last crop of rice has been harvested; the land is irrigated at this stage and also, if possible, after each time the crop is out for fodder.

24. *Artificial Fertilizers*.—It is only within recent years that the ryot has taken to using artificial fertilizers. The Agricultural Department were responsible for their introduction which was so successful that now the co-operative societies and commercial firms have undertaken to supply these manures. Phosphatic fertilizers, and ammoniacal manures, and manures yielding ammonia under anaerobic conditions have all proved very valuable. Nitrate fertilizers have not proved satisfactory.

25. *Sowing*.—Rice is generally transplanted but there are a few peculiarly situated areas where sowing gives better results for the first crop at any rate; such areas are the low-lying sandy lands found near Mangalore, on the West Coast, where seed is sown behind the plough. The seed is scattered along the furrow and is covered over by the ridge made by the next turn of the plough (country plough). If the seed comes up too thickly the surplus seedlings are removed and transplanted elsewhere. Direct sowing is also practised in areas subject to early or rapid flooding, the land being ploughed during the dry season and the seed sown broadcast at the commencement of the monsoon.

26. *Transplanting*.—This operation is done by the women. No transplanting implement, such as is popular in Sierra Leone, is used nor is any necessary as the rice is always planted in puddle. The number of seedlings planted in a stand varies greatly; where holdings are small and transplanting is carefully done only two or three seedlings are planted together but in some districts a larger number—even up to eight or ten—may be planted in a single stand. The usual planting distance is 6" x 6" but this distance depends greatly on soil and variety. Early varieties may be as close as four to six inches but late varieties are generally six to nine inches apart. The Agricultural Department strongly recommends thin planting—singly or in pairs—and there is no doubt that many farmers have adopted this method with much benefit.

(iii) *Upland Rice.*

27. I have mentioned the cultivation of upland rice in Malabar and Kanara. The area devoted to this crop is comparatively small and is limited to the more level slopes above the single-crop wet lands; the fields are not levelled or bunded, and indeed the system is comparable to our method of growing upland rice in Sierra Leone and has nothing to recommend it. The rice crop is followed by a crop of sweet potatoes, benniseed, horse gram or *Panicum miliare*, after which the land is left fallow for three to four years. The land is ploughed eight to twelve times between the end of the monsoon and sowing. Wood ashes may be applied at the time of sowing but no other manure appears to be given.

(iv) *Rice Cultivation in Saline Lands.*

28. This is of interest to us in Sierra Leone, as once the ordinary swamp lands are more fully exploited the people will endeavour to extend cultivation into the saline lands of the creeks and river estuaries. The subject is referred to in detail in Appendix II.

(v) *Rice Cultivation in Deep-water Areas.*

29. In Sierra Leone there are many extensive areas of deeply flooded lands, mostly low-lying areas behind the marginal lands of the river deltas. At present these lands are little used for rice but potentially they are of great value. When in India I heard, and in some cases saw, how similar areas are utilized for rice. The three chief methods are—*(a)* By using deep-water varieties. *(b)* By pumping out or draining off water. *(c)* By growing a crop after the floods have subsided.

(a) By Using Deep-water Rices.—This is the simplest method, no elaborate irrigation or drainage system being necessary. Deep-water rices can be divided into two classes: tall strong-strawed rices like "Panianala," "Harisankar," "Baitel Fakir," "Konamani," "Akulu" and "Kar"; and floating rices of the type grown in Indo-China. The former type will not do well where the depth of water is more than four to six feet but the floating rices will withstand a much greater depth if the rise of flood water is not too rapid. The rice may be sown broadcast or transplanted, but whichever method is adopted it is essential that the rice should be established before heavy flooding takes place. At Arupthi near Mayasaram on the East Coast of Madras, I visited a flood area which is planted every year with the variety known as "Kar," a six months rice with red testa. This area is dry for only a short period of the year and for several months it is flooded to a depth of four to six feet. The land is ploughed as soon as it begins to dry after the floods subside; this leaves the land in a very rough condition but a further ploughing is done when the first flooding takes place and this breaks down any remaining clods and quickly produces a good puddle in which the rice is planted without delay. Semi-dry nurseries are used but as no rain falls during the time the seedlings are in the nursery, it is the practice to dig temporary wells from which periodical irrigations are given to the seed beds.

(b) By Removing Excess Water.—In Sierra Leone there are some deeply flooded areas which could probably be made suitable for rice (ordinary rices) by simple drainage; in India such areas have long ago been utilized, and, in addition, areas which cannot be

satisfactorily treated by simple drainage are made available by pumping off the excess water. This method is practised on the Malabar Coast in areas similar to the deeply flooded swamps, some of them perennial, which lie behind the marginal lands of the Scarcies deltas. In Malabar such lands are known as "Kole" lands and the method of cultivation is called "Kole" cultivation. These "Kole" lands are perennial swamps which assume lake-like proportions in the wet season but dwindle to a varying but considerable extent during the dry weather; and they are brought under cultivation by the following method. The area is divided into large blocks of 100–200 acres, separated from each other by canals, fifteen to twenty feet in width, which are made by packing kaolin clay between double rows of strong stakes. These canals serve as drainage channels as waterways, and also as reservoirs for irrigation. During the rainy season the bunds are completely submerged but in December, after the cessation of the North-east monsoon, the floods subside somewhat although the fields still remain flooded. The water is then pumped from the fields into the canals by contractors who charge a rate of Rs. 15 per acre; formerly water wheels were used for the purpose but now oil-driven pumps are fitted upon the bunds. The canals, the surface of which is above the level of the fields, are connected up with the nearest creek by a drainage channel which is provided with a transverse bund to prevent the ingress of salt water during the dry season, and also to hold back sufficient fresh water for irrigation purposes. The rice generally grown in these "Kole" areas is a short duration (four months) variety called "Thekkancheera." The germinated seed is sown broadcast on the mud. The fields which are sub-divided by small bunds are sometimes ploughed but usually this is not possible. No irrigation is necessary until two or three weeks after sowing, but as soon as the soil begins to crack water is let in from the canals and allowed to stand at one to two feet. Further drainage and irrigation takes place at least once. I wish to point out that I had no opportunity of witnessing "Kole" cultivation in progress and that I am indebted for most of my information to Mr. Anantan who was at one time Superintendent of the Pattambi Agricultural Research Station.

(c) *Cultivation after Floods have subsided.*—In the Collair Lake tract, on the East Coast, rice, in addition to being grown in the ways just mentioned, is also grown in areas from which the flood water has subsided. In this system rice is grown in bunded fields which are irrigated with water led back in channels from areas which are still flooded, cultivation commences on the periphery of the deeply flooded area and is extended as the waters go down. The water is usually raised from the channels into the fields by a trough lift; it is necessary to deepen the irrigation channels as the flooded area diminishes.

30. *Development of Flood Areas in Sierra Leone.*—All the methods used in India could be adapted to Sierra Leone conditions, but at present it is unnecessary to consider the use of pumps or elaborate drainage schemes. There are however tracts in the deltas which can be made available by simple drainage and the use of suitable deep-water rices, although I do not think there will be much development until the mangrove swamp lands are fully exploited; this stage is now being reached in some sections of the Scarcies deltas. Three varieties of deep water rice—Panianala, Harisankar and Baitel Fakir were obtained in India and it is hoped to try these in suitable areas.

WORK OF THE MADRAS DEPARTMENT OF AGRICULTURE TO IMPROVE RICE CULTIVATION.

31. In many parts of India there is a danger of an over production of rice, and the present policy of the Madras Agricultural Department appears to be to encourage the reduction of the area devoted to rice except in localities which are particularly suited to this crop; elsewhere the cultivation of other food crops is advocated. Where rice is considered to be the most profitable crop the Department's aim is to increase the yield and to improve the quality. A large staff is engaged in the improvement of the rice crop; specialised officers are responsible for research and breeding investigations but the District Agricultural Officers play a big part in the dissemination of improved seed and better cultural methods.

32. *Research Stations.*—The Department has a Central Research Station at Coimbatore which is directly supervised by the Paddy Specialist. There are in addition three other main Research Stations, one on the West Coast and the other two on the East Coast: each of these stations is in charge of a Superintendent who, in addition to having a practical knowledge of rice farming, is also fully qualified to do plant breeding and to carry out scientific investigations in connection with cultural methods. The Department aims at having one of these stations in each of the important rice areas. Each station makes a special study of the rices and conditions in the surrounding tract. The more important aspects of the work done include the following:—

- (i) *Plant Selection.*—For the isolation of superior strains from the best local varieties. Superior strains are pure line selections which give a higher yield than the local farmers bulk crop, whilst retaining or improving its quality and its suitability for peculiar conditions of soil, flooding, drought, or salinity—as

the case may be. Large quantities of tested selected seed have been distributed during recent years and have with few exceptions given yields of from 10 per cent. to 30 per cent. more than those obtained from the farmers' ordinary seed.

- (ii) *Hybridisation*.—To evolve new types combining the desired quality of two varieties.
- (iii) *Investigation of Cultural Methods with a View to Improvement*.—Resulting from such work in the past the Department now strongly recommends more economical sowing and transplanting rates. Single planting is usually advocated but in unfavourable conditions, and with varieties which do not tiller well, two or three seedlings to the stand may prove a more economical rate.
- (iv) *Trial of introduced Varieties*.—Occasionally this gives good results, but as a rule the selection of superior strains from existing varieties is the best method; rice cultivation is of such long standing in India that most areas appear to have evolved varieties particularly suited to local needs.
- (v) *Experiments with Implements*.—Ploughs and harrows likely to be an improvement on the indigenous implements are being tested.
- (vi) *Manurial Experiments*.—These have been conducted for many years, and the Department has been enabled to make recommendations which have proved very profitable to the farmers who have adopted them.
- (vii) *Experiments with other Crops*.—With a view to making recommendations as to what crops can be profitably rotated with or substituted for rice.

33. *District Work*.—The work done in the Research Stations is brought to fruition in the districts through the medium of the Agricultural Officer and his demonstrators. Selected strains are subjected to trial under supervision on the ryots' farms, and, if results are satisfactory, steps are taken to make seed available for general distribution; propaganda with reference to the adoption of improved cultural methods and the use of manures is effected in the same way.

34. The rapid dissemination of improved strains and the maintenance of their purity are by no means simple when large quantities of seed are involved as only comparatively small quantities of seed are available each year from the Government Stations, and so methods of supplementing this source are desirable; the following are the methods which have been adopted in the fifth Circle:—

- (i) Seed (small quantities) is sold direct to the farmer from the Government Stations.
- (ii) Seed is given gratis to the farmer on the condition that the crop is kept pure and that five-sixths of the produce, together with the quantity originally received, is sold back to the Department at market price plus a premium of two annas per kallam (a kallam is a measure of volume equivalent to about 64 lb. of paddy)—The paddy is bought wet, and drying and storing are done by Government.
- (iii) Seed is given to the farmer on the condition that he sells at least 50 per cent. of his crop to his neighbours.
- (iv) The seed bought as mentioned in (ii) may be re-issued in any of the ways described in (i), (ii), (iii) and (v).
- (v) Seed is sold to the Co-operative Agricultural Societies. As a rule the society selects a dependable farmer to grow and multiply the paddy; and after harvest the crop is divided (sold) among the members.

N.B.—In (ii), (iii) and (v) roguing, under departmental supervision, is compulsory.

RICE MILLS.

35. In the Madras Presidency both raw and parboiled rice are produced but the chief demand is for the latter. On the West Coast rice is parboiled and the husks removed in the same way as in Sierra Leone, but in the deltas on the East Coast mills are plentiful. A certain amount of rice is exported from Tanjore to other parts of India and to Ceylon, but the greater part is consumed locally, and the milling industry is primarily a rural one. There are only a few large mills and most of the rice is treated in single hullers operated by oil-driven engines. The industry is a comparatively recent one and may be said to have begun in 1910, since when there has been a very rapid expansion until to-day there are several hundreds of these small mills. The first mills were a great financial success but there are now many more mills than can be profitably employed and most of the mills

are running very irregularly. There are a few large scale cone mills which can turn out up to 8 tons per day, but the great majority of the mills are fitted with single hullers—chiefly of the Engleberg type—with a capacity of 3 to 5 tons per day. The Engleberg mill consists of two superimposed cylinders, one being the huller and the other the polisher; in the Tanjore delta the polisher is not used but the rice is passed through the huller twice.

36. In many cases the milling is done for local farmers who bring in their paddy already parboiled and for this the milling charge is about one penny per bushel. Some of the mills export rice and in such cases the paddy is purchased from local farmers but the parboiling is done by the miller. The paddy is soaked for twenty-four hours in cement steeping tanks and then steamed for thirty to forty-five minutes in rectangular metal tanks which are fitted with grids on which the rice is placed; there is a space for water below the grid and steam is generated by the heat from a furnace underneath the tank; rice husks are used for fuel. In some of the larger steam-driven mills a more elaborate method of steaming may be seen: the steaming vessel may be cylindrical tank with a capacity of up to fifty bags; a vertical pipe with perforated branch pipes is fitted to the centre of the tank and when steam is required the steam pipe from the boiler is connected to the vertical pipe of the tank. On removal from the steaming tanks the paddy is spread out on a brick or mud floor where it is exposed to the rays of the sun for about twenty-four hours. The right degree of drying is important as there will be undue breakages if the paddy is either too wet or too dry; the paddy is not milled immediately after drying but is stored for about one week.

B—CEYLON.

INDIGENOUS METHODS.

37. The indigenous methods do not merit detailed description. Both upland and wet-land rices are grown; the former is most important crop under “Chena” cultivation which is a system of farming similar to that of shifting cultivation as practised in Sierra Leone. There is, however, a greater area devoted to wet-land rice which is cultivated in banded fields as in Madras. In the drier parts of the Island—the Jaffna Peninsula excepted—the crop is irrigated from large reservoirs which are known locally as “tanks”; but in the wetter and hillier zones the crop depends for its water supply on the direct rainfall supplemented by small streams, formed by surface flood water. Usually the water is allowed to pass from field to field through breaches in the bunds. The Ceylonese display great skill in terracing the hill sides. It is noticeable that, generally speaking, the crop does not receive such particular attention as is given to it in Madras, and this is largely due to the fact that in many areas the people are more interested in the major plantation crops; in addition the holdings are frequently so small as to be uneconomic in size, a condition which is said to be a result of the law of inheritance which decrees that the property of the father is to be divided equally among his sons.

38. There are two rice seasons: the “Maha” or long season lasting from September to March, and the “Yala” or short season lasting from April to August. The fields are prepared by two or three ploughings with the country plough: the plough is followed by the levelling boards; the first a large plank drawn by buffaloes and the second the small hand level. In very small fields a mamotty may be used instead of the plough; and in some areas, where the mud is deep, a puddle is obtained by the method known as “mudding,” which consists in driving a team of buffaloes around the field until the surface has been reduced to puddle.

39. Manuring is not always practised although it is usual to apply green leaves or other organic matter between the second and third ploughings; artificial fertilizers are not used as yet.

40. For the “Yala” crop the seed is always sown broadcast, and for the “Maha” crop only 25 per cent. of the farms are planted. The seed rate may be as much as two or three bushels per acre which seems excessive, but weeding is not done very carefully and for this reason a high seed rate is considered beneficial in checking the growth of weeds. Seed is sometimes sown dry but the usual practice is to broadcast germinated seed in puddle. Seed is germinated by soaking it overnight in a gunny bag, or other suitable receptacle, which has been immersed in a convenient stream or pool. When the soaking process is over the superfluous water is drained away and the seed is heaped on banana leaves in a cool dark place; more banana leaves are placed on top and weights may be superimposed if rapid germination is required.

WORK OF THE AGRICULTURAL DEPARTMENT.

41. The Ceylon Government is fully aware of the importance of improving the rice crop, and, for some years, the Agricultural Department has been engaged in a programme of work which must eventually produce very beneficial results. The primary

object is to increase the yield per acre and to improve the quality of the crop, and with this end in view, superior strains of the best local varieties are being isolated and, if satisfactory when carefully tested, they are multiplied and distributed to the farmers. When engaged in selection work it has been found that conditions vary so much within small distances that it is desirable to make special selections from each particular district. The initial field selections (ear heads) are made in the area for which the improved strain is required; and although the preliminary selections of strains have so far been made at Peredeniya it has been found that no selection can be considered to be an improved strain until it has given increased yields in the area from which the original seed was obtained.

42. The Economic Botanist is responsible for the initial testing of selections, and those which are passed by him are submitted to field trials in the area for which they are intended; these trials are usually carried out on one of the Paddy Seed Farms which are now established in all the important rice areas. If the field trials prove satisfactory the seed is multiplied and finally distributed to local farmers. The seed farms are controlled by the local District Agricultural Officer or Senior Agricultural Instructor; but the Economic Botanist is responsible for uniformity of field methods and also for the maintenance of purity of the selections.

43. There are twenty-three seed farms of an average size of five acres: these farms appear to be satisfactory; but I was told that, even though they are so many, they are inadequate for meeting the demand, so large is this, for pedigree seed; and it seems possible that the multiplication and distribution of seed will shortly be taken up by private individuals.

44. In addition to selection work, the Economic Botanist is carrying out manurial and cultural experiments. The use of artificial fertilizers has led to beneficial results and definite treatments are now being demonstrated on the Paddy Stations and Seed Farms.

45. Hybridisation is not considered advisable at present as it is thought that better results can be obtained, for some years at any rate, by making pure-line selections. Some details of selection work in Ceylon will be found in Appendix III.

SUGGESTIONS FOR AN IMMEDIATE PROGRAMME OF WORK IN THE RICE AREAS.

46. On account of present financial stringencies, it is realized that any programme of work for the immediate future must be one that can be carried out, with a small expenditure of money, by the existing staff. The establishment of at least one rice station, with adequate facilities for experimentation and breeding work, is desirable; and should be provided for when the financial position of the Colony permits it. In the interim there is much that can be done in a simple manner that will directly encourage rice cultivation and at the same time increase our knowledge of conditions in the rice areas.

47. *Delta Rice Lands.*—The following remarks and suggestions refer particularly to the Scarcies-Rokel delta areas. Obvious lines of work include the extension of the area cropped, the improvement of the crop with regard to yield and quality, and the improvement of the economic position of the rice farmer. Possible methods of effecting a commencement towards these improvements are considered.

48. *Staff.*—The Agricultural Officer, in whose Circle the area lies, should devote as much time as possible to a study of conditions in the tract; and should endeavour to establish personal contact with the rice farmers. He should have under him two subordinate officers, and I suggest that these should be of the ranks of overseer and instructor. When a rice station is opened an overseer will be required for work there; and in the interim he and the instructor can be usefully engaged in itinerant duties.

49. *Investigational Studies.*—Although the Scarcies-Rokel area has been the subject of an agricultural survey, nevertheless there is much to be learned about conditions there, and further and more detailed information is required with regard to the following aspects of rice cultivation:—

- (a) Suitability of areas not yet brought under cultivation, and the feasibility of extending double cropping.
- (b) Existing cultural methods in nursery and farm, and their variations according to different conditions of soil, flooding and salinity.
- (c) Method of harvesting and of storing thrashed and unthrashed grain.
- (d) Characteristics of all the important varieties of rice.
- (e) Measurements of crop yields, and of sowing and planting rates as practised under varying conditions.

(f) Pests and diseases.

(g) Social and economic conditions generally, with special reference to land tenure and marketing.

50. *Seed Selection*.—The isolation of superior strains of the best varieties, and the distribution, after careful trial, of this pedigree seed, multiplied on seed farms has given amazingly good results in India. Until a rice station is established it will not be possible to undertake similar measures in Sierra Leone, but valuable work can be accomplished without delay by assisting the rice farmers to make mass selections on their own farms.

51. At harvest time, but before the crop is cut, the farmer should be shown how to select the panicles of the best plants, taking particular care to see that all are of the desired variety. The selected seed should be stored separately and subsequently kept apart in both nursery and farm. The crop raised from the selected seed will not be quite pure but it should be a decided improvement on the rest of the farm. Undesirable plants in the area grown from selected seed should be rogued out as early as possible. By such a process of selection and multiplication, repeated as necessary, it should be possible for any keen farmer to improve the quality as well as the yield of his crop.

52. The value of such a scheme would be greatly augmented by making it possible for farmers not already possessing any, to obtain good strains of these varieties; and, in the absence of proper seed farms, it is suggested that farmers who are known to possess good strains—and such people exist—should be encouraged to grow crops for seed. Private seed farms are not likely to prosper at the moment, but farmers working under Government supervision can easily be induced to grow rice for seed purposes if they know that Government will guarantee a fair price for it. The general supervision, including mass selection, of these farms, which would be quite small at the beginning, would be done by the Agricultural Officer and his staff; the resulting crop would be bought and distributed to applicants, who are certain to be forthcoming not only locally but also in more remote parts of the Colony. One the best and most popular rices in the Scarcies area at the moment is Pa Fodea, which is said to be a selected strain of Pa Litoma; this rice is spreading slowly but its distribution could be quickly extended by the adoption of the above method.

53. The importance of using good seed cannot be over emphasized. At present the majority of the farmers use mixed seed which gives rise to a crop that ripens unevenly, with grain that is not uniform in quality; if rice milling is introduced it is very important that the grain should be as uniform as possible. It is also important that white-riced varieties should be encouraged in preference to red; unless the latter meets some specific local need which cannot be otherwise provided for. In the Scarcies area there are some excellent white-riced varieties which should be encouraged as being suitable for export as well as local needs; I refer particularly to the varieties known as Pa Indian, Pa Kanlu (or Pa Wo), Pa Fodea, Pa Bis and Pa Kalimodu; Pa D.C. is also worth fostering, on account of its excellent quality and its suitability for areas where early maturity is essential, although being of the Patna type it will be more difficult to mill than the other varieties which are of the American type. When mills are established it is assumed that better prices will be given for uniform grain of the best white varieties; this will be an incentive to seed selection.

54. To encourage seed selection it may be found beneficial to hold Paddy Sheaf competitions similar to those in vogue in Ceylon. Prizes are given to farmers who produce the best sheaves of the varieties that it is wished to encourage. The Agricultural Officer takes advantage of the occasion to emphasize the importance of using good seed, and all those who have good samples are urged to sow them separately for multiplication.

55. *New Varieties*.—It may be that the improvement of existing varieties will give better results than the introduction of new varieties; but at the same time, the possibility of successfully introducing new varieties must be considered. The local farmers are always keen to experiment on a small scale with new varieties. Pa D.C., which is now so popular, is a recently introduced variety, and several other important established varieties owe their origin to seed accidentally imported in straw used for packing purposes.

56. When in India and Ceylon I obtained, after careful consideration of our needs, a number of varieties which would appear to be worthy of trial in Sierra Leone, and of these varieties the following may prove valuable in the Scarcies and similar areas:—

(a) *Ordinary Deltaic Conditions*.—G.E.B. 24, C.O.5., C.O. 7., Adt. 1., Adt. 5.

(b) *Saline Lands*.—Bali, Orkayama, Kultooth.

(c) *Deeply Flooded Areas*.—Panianala, Harisankar, Baitel Fakir.

(d) *Double-crop Lands*.—Adt., 3.

It is understood that it would have been better to have first tried these rices on a Government Station, but, in the absence of such facilities, I suggest that *small* trials be made with the assistance of local farmers. The farmers will be quite willing to co-operate, and it can be pointed out to them that the trial is purely of an experimental nature and success cannot be guaranteed. If a trial is successful the crop can be purchased from the farmer; and in the case of failure compensation can be arranged.

57. *Cultural Methods*.—Here again there is need of accurate experimental work, but with the co-operation of the farmers it will be possible to make a beginning with investigations along promising lines. In such case it is suggested that the investigations be limited to a *small* portion of the nursery or farm.

(i) *Nurseries*.

- (a) Try lower seed rate.
- (b) Cultivate thoroughly, and apply village refuse, ashes, etc., when available.

(ii) *Farms*.

- (a) Transplant fewer seedlings to stand; if a lower seed rate is used in the nursery the individual seedlings will be stronger and can be transplanted more economically; three to the stand is probably the best number in the tidal areas.
- (b) Do not leave the seedlings too long in the nursery; this is a common fault.
- (c) In the weedy occasionally-tidal lands, simple bunding should be tried; such a measure would facilitate transplanting and would be useful in checking weed growth.
- (d) Deep-hoe before transplanting; this will certainly be of benefit in the less tidal areas and may even be worth doing in the mud lands of the tidal areas.
- (e) Plough in non-tidal grasslands.
- (f) In saline lands try the effect of draining, and also of heaping the land so that the salt may be more easily washed out of the soil when the rains commence.

58. *Inland Swamp Areas*.—The propaganda carried out, during the last few years, by the Agricultural Department, assisted by the Political Administration, has resulted in a very considerable increase in the area under rice in the inland swamps. Although there is now no shortage of rice in most areas yet this work should be continued, as the development of the swamp lands is of great importance as a step towards the abolishment of shifting cultivation. It is thought that at least one Agricultural Instructor in each Circle might have special training in rice work although general propaganda can be done by all members of the staff.

59. *Investigational Studies and seed selection work* may be modelled with a few modifications on the lines indicated for the delta areas in paragraph 49 to 54.

60. *Trial of New Varieties*.—Wet-land cultivation has not existed so long in Sierra Leone that one can say that each district has evolved or obtained the varieties most suited to its conditions and needs; and it seems advisable to experiment in each area with carefully selected exotic varieties as well as with the best varieties from other parts of Sierra Leone.

61. *Cultural Methods*.

- (i) *Nurseries*.—Lower seed rate; and thorough cultivation if soil is poor.

(ii) *Farms*.

- (a) Dig thoroughly to produce a puddle and to bury all vegetation.
- (b) Transplant singly where conditions are favourable; elsewhere in twos or threes not more.
- (c) Investigate the possibilities of levelling, bunding, and water control. The farmer will not be prepared to adopt any elaborate measures unless he is cultivating the same land every year; all the same he will frequently find it possible to make temporary bunds which, with a small expenditure of labour, will repay him handsomely for his trouble. Three of the most potent causes of poor wet-land crops are weeds, lack of depth of water, and soil wash: even a simple system of bunding would enable the farmer to overcome these difficulties.
- (d) Utilize the plough for large swamps.

- (e) Investigate the possibility of double cropping. This should be possible in most wet lands which are not subjected to deep flooding; and it is certainly feasible in areas in which water control is possible. It must be remembered, however, that if it is desired to raise two crops under ordinary rain-fed conditions it will be necessary to plant out the second crop not later than September; and this means that the first crop will need to be harvested in August when the rains are at their heaviest and conditions for harvesting unsuitable. An early ripening crop will also be seriously attacked by birds. Personally I do not advocate double cropping but prefer to see a crop of rice taken in the rainy season and sweet potatoes grown in the dry season; even where irrigation is possible, I favour a single crop of rice followed by vegetables crops.

SUGGESTED PROGRAMME FOR EXTENSION WORK IN SIERRA LEONE.

EXPERIMENTAL STATION—DELTA RICE AREA.

62. *Purpose.*—When funds are available, a Paddy Breeding Station should be opened in the Scarries rice area. The chief object of the station would be the production of improved seed for supply to the farmers in the delta rice areas; but, in addition, experiments should be carried out to determine in what manner the indigenous methods of cultivation can be improved.

63. *Location.*—With regard to the best site for a rice station, I have already suggested and stated the reason for my suggestion—in my report on the Scarries rice areas—that the most suitable location is to be found in the neighbourhood of Bumbe on the Great Scarries River; I have not altered that opinion, although I should not like to suggest the exact position for the farm until I have made further investigations on the spot. With regard to the size of the farm I consider that, at the outset at any rate, 10 acres of wet land and 3 acres of upland will be sufficient.

64. *Staff.*—The supervision of such a station will demand practically the whole-time services of an Agricultural Officer, especially during the first few years when the station is being opened up and the African staff is being trained. The African staff required will be two field assistants and a clerk, who can also help with laboratory work.

65. *Buildings.*—Accommodation will be required for the Agricultural Officer and his staff; and, in addition, an office as well as a laboratory and seed store will be required.

66. *Cost.*—The cost of the buildings and equipment will be about £1,000; and, excluding the Agricultural Officer's salary, there will be an annual recurrent expenditure of about £400, as follows:—

	£
Salaries of African staff	200
Labour	160
Rent	10
Incidentals	30
	£400

67. *Lay-out.*—On all Paddy Breeding Stations in the East controlled irrigation is possible; but, in the Scarries River areas water control is unknown. I consider however that, even if irrigation is not controlled, it is essential to lay down a system of bunds, if only for the purpose of giving access to the different parts of the farm. Fields can be large as the farm will be situated in the level marginal lands; half-acre fields will probably not be too big. The main bunds should be four feet in width and the subsidiary bunds eighteen inches in width. Channels may be one to two feet in width according to their position on the farm.

68. *Programme.*—Before any experimental work is started, the various fields should be tested for soil homogeneity by one of the recognized methods. Selection work should, in my opinion, be based on the methods now employed by the Madras Agricultural Department. Pure line selection is recommended as the best method of effecting seed improvement, but, as it takes at least eight years of selection, testing and multiplication, before a strain improved in this way is available for general distribution, it is recommended that mass selection work with the best local varieties should also be carried out during the early years of the farm. Selection by hybridisation is considered unnecessary at present. In addition to selection work the station should carry out character studies of all the important rices, and also investigate the possibility of improving existing cultural methods; the most promising lines of investigation have already been referred to in paragraphs 49 and 57. As wet nurseries are unknown in Sierra Leone, I am therefore of the opinion that we should use dry nurseries on the Paddy Station, although, if this method is used, great care will be necessary to ensure uniformity of conditions; at the same time the possibility of adopting the wet or semi-dry nursery systems should be investigated.

69. *Experimental Station—Inland Rice Areas.*—At a future date it will be advisable to establish an inland Paddy Breeding Station at a central place, such as Magburaka or Makeni, to demonstrate the fuller development of swamps of the inland valley type. Such a station would carry out cultural investigations and also do seed selection. Water control and the cultivation of subsidiary crops should receive attention as I am of the opinion that if we are to reduce the area under shifting cultivation we must make wet-land farming as attractive and as remunerative as possible.

70. *Seed Farms.*—Government seed farms, such as exist in Ceylon, would prove a valuable complement to the Paddy Breeding Stations, although I think that multiplication of seed can be more cheaply and simply effected by co-operating with intelligent farmers who may be prepared to undertake this work under our supervision.

PROSPECT FOR RICE MILLS IN SIERRA LEONE.

71. The use of rice cleaning machinery in the chief rice producing areas seems very desirable as at present there is an enormous waste of manual labour in the preparation of the crop for the market. It is believed that mills could be profitably installed in the main rice areas, particularly those of the Scarcies rivers. A carefully controlled export trade would give an impetus to rice cultivation. In this connection, it is necessary to remember rice is the staple food crop of the country, and not merely a money crop; and, consequently, too large an export will result in a shortage and high prices. In addition, an export trade, if not controlled, may lead to an increase in upland farming which is not desired; every effort must therefore be made to meet any increased demand by increasing the area under wet-land cultivation.

72. With regard to the erection of mills there is no doubt that there is room for at least one large mill in the Scarcies area; and the most suitable location for this would appear to be Kichom, on the Great Scarcies, as this point is easily accessible from the main rice areas of both rivers. The majority of farmers in the Scarcies area would welcome the establishment of mills. It is probable, however, that the women who now undertake the parboiling and cleaning of the rice will view the prospect with great disfavour; but this is unavoidable and no doubt they will soon adjust themselves to the situation. There are also, in my opinion, good prospects for a small mill in the Port Loko Creek (where the rice is of particularly good quality) as well as at several places in the hinterland; I have especially in mind Mano, Yonibana, and Magburaka, which are the chief marketing centres of the important rice-producing areas.

73. With regard to the best type of machinery to instal, this will depend entirely on the quality of rice required, which depends, in turn on the market catered for. If the rice is required for marketing on the West African Coast, and this appears to be our best outlet, then a self-contained mill on the Rangoon system is desirable, and this is the type I would suggest for the Scarcies area, although smaller mills might also be profitably there. For up-country stations, I favour the installation of small mills fitted with combined hullers and polishers of the Engleberg type, as in these areas it seems advisable to aim at producing a rice for local consumption rather than for export.

74. For local consumption parboiled rice is more suitable than "raw" rice and the main demand is for this kind of rice. Parboiled rice is preferred by the working class as it is more satisfying; in addition, it mills more easily and has better keeping qualities. For the local market it is neither necessary nor desirable to do more than remove the husk and a small portion of the pericarp.

75. Mills of the Engleberg type are only suitable for dealing with parboiled rice, and, when used for milling "raw" rice, the percentage of broken grains is very high. Rice treated in mills of this type could be sent, if not required for local consumption, to a central mill at Freetown for milling up to the standard required for export.

76. It should be borne in mind that the production of parboiled rice will be very difficult, if not impossible, during the rainy months: the installation of drying machinery is unlikely to prove profitable and parboiling must therefore be done during the dry season.

77. To encourage firms or individuals to erect machinery it is desirable, in my opinion, that they should be able to obtain a concessionary right, for a stated number of years, which would limit or prohibit the erection of other mills within a certain radius, the distance depending on the capacity of the mill; always provided that, in a centre where there is work for more than one mill, concessions should be granted if necessary to several individuals. I consider it important to have mills in the actual rice areas as the eliminating of the middle-man, so far as is possible, will mean bigger profits for the producer.

78. If milling for export is to be established it is most important that the Agricultural Department should assist the farmers to produce white-grained crops of uniform quality, as the presence of red-grained rices, and rices of mixed sizes, results in heavy milling losses. I understand that a sample consignment of paddy, recently sent home by one of the local firms, milled very badly; on account of the unevenness of the grain only 50 per cent. was shelled on its first passage through the mill; and any attempt to obtain better results produced an excessive percentage of broken grains. Another fertile cause of excessive breakages may be traced to sun cracks which are the result of careless methods of drying and storing the paddy.

III—GENERAL AGRICULTURE. AGRICULTURAL SYSTEMS.

CEYLON.

79. Plantation crops, grown chiefly under European supervision, are the outstanding feature of agriculture in Ceylon, and consequently it is not surprising to find that peasant agriculture has received comparatively little attention in the past; the fact that Ceylon annually imports over 400,000 tons of rice is significant. The cultivation of wet-land rice has already been described. "Chena" cultivation, which is similar to our own system of shifting cultivation, is practised over a great part of Ceylon although it is not such a dominant feature of agriculture as is shifting cultivation in Sierra Leone. The Agricultural Department is now endeavouring to evolve a system of arable farming, which, by the judicious rotation of crops, will make permanent cultivation of the same land a possibility. No doubt good results will be obtained on the Government farms but its adoption by the native farmer is improbable as it involves manuring and the use of green manure crops.

80. In the Jaffna Peninsula, a level stretch of land with a low rainfall and no surface water supplies, a very interesting system of intensive cultivation is in force, by means of which tobacco and garden crops are grown under well irrigation. Some aspects of this system can be carefully adapted to the dry season cultivation of garden crops in valley bottoms in Sierra Leone.

MADRAS.

81. There is no need to describe the agricultural systems of the drier zones which are dependent on elaborate irrigation systems. I have already referred to the striking resemblance of climatic and soil conditions in Sierra Leone to those existing on the West Coast of India. Agriculturally, however, Sierra Leone is very backward and she can learn much from the farmers of the Malabar and Kanara Districts. I have in mind the maximum development of the valley bottoms for the cultivation of rice in the rainy season, and of garden crops, with the assistance of irrigation as necessary, in the dry season; the extension of the normal swamp area by levelling and bunding the lower slopes of the valley sides; the more extensive cultivation of fruit trees and garden crops in the vicinity of dwelling and farm houses; the cultivation of coconuts, cashew and casuarina in lands unsuited for other crops; the use of cattle for draught purposes and to provide manure; and the reservation of bush areas on the higher lands for the purpose of providing timber, fire-wood, and leaf manure. It is realized that the general adoption of these practices will take a very long time as weighty social issues are involved.

SIERRA LEONE.

82. In developing agriculture in Sierra Leone we must face the fact that we can hardly hope to abolish the present system of shifting cultivation, although we may be able to limit and modify it. Our chief aim should be the fullest possible development of the wet lands for rice and garden crops as this is the surest way of reducing the area under upland shifting cultivation.

83. A still further reduction can be obtained by increasing the area devoted to fruit trees and garden crops in and around the villages; this can be encouraged by supplying planting material; and by inducing the villagers to build their houses further apart so that each house is surrounded by a fairly large garden. It will not be easy to effect this spreading out as the villagers are conservative on this point for social and sentimental reasons; but that it can be done in time I have little doubt. I have already noticed that in some of the more developed areas—particularly in the Port Loko District—there is a growing tendency to build houses—especially those belonging to newcomers—in extended order along the roads leading into the village; most houses so situated have good sized gardens devoted to root crops and vegetables and I notice that some owners now manure their crops with wood ashes, rice husks and other organic refuse which is applied during the dry season. The system, advocated by this department, of growing yams in

well manured trenches has now taken firm hold and is a decided step forward in garden cultivation. I am of the opinion that manuring for other intensively cultivated crops can also be successfully demonstrated.

84. Although it is obvious that garden and wet-land cultivation will increase considerably, nevertheless shifting cultivation in some form or other will probably continue to flourish for centuries. Even on the West Coast of India shifting cultivation of a primitive type still persists, although the reservation of bush to provide leaf manure and timber is not interfered with. Personally, I cannot believe that a really satisfactory system of arable farming can be devised for the Sierra Leone farmer as he will not be prepared to manure his upland farm as long as he can turn to bush or grassfields which will grow crops without the application of manure. In addition, I am of the opinion that in bush country any attempt by the farmer to carry out intensive cultivation, except in garden and wet lands, will lead to a more rapid destruction of bush than does the existing system of shifting cultivation.

85. This department is at present advocating the delimitation of soil erosion belts and this may produce good results. In addition it would be well if every village could be induced to set aside an adequate area of bush to provide timber, firewood, and leaf manure.

86. In bush country it is now the custom to clear a fresh area for each year's farm; although, if the bush is young, the land may be cropped for two years before it is allowed to revert to fallow. In the grasslands of the Northern Province the farmer cultivate the same piece of ground more frequently and for longer time; the following crop rotation, which is practised in the Biriwa Chieftdom, is representative:

1st year, rice.

2nd year, ground-nut.

3rd year, *Digitaria* followed by sweet potato.

4th year, rice or fallow.

A fallow of three or four years separates the cropping periods. No manures are applied, and although the system appears to give fairly good yields it has two serious faults; soil erosion is very severe on sloping ground and may eventually reduce the land to such a state that it can no longer produce a paying crop; continued cultivation encourages the establishment of weeds of which the most pernicious is lalang grass, and indeed in some areas this grass has now obtained such a hold that its eradication appears to be well nigh impossible. I do not think we can expect the native farmer to adopt a more elaborate system of arable cultivation than this although we may be able to do something to remove its greatest drawbacks which are the facilities it offers for soil erosion and weed growth.

PERENNIAL CROPS.

87. In India and Ceylon I had excellent opportunities of seeing all the important perennial crops, but in this report I do not refer to certain plantation crops such as tea, rubber, and cinnamon which are not of direct interest to us in Sierra Leone.

88. *Cacao*.—In Ceylon I visited several of the important estates in the Dumbara valley. There is little resemblance between these well organised estates and the small plantations of the Sierra Leone villagers, but certain points in their management are instructive.

89. The plantations are clean weeded. Every second year forking is done and followed up a few weeks later with a heavy dose (600 lb. per acre) of artificial fertilizers. Farm-yard manure is applied if available. All suckers are carefully removed unless required to replace a missing branch or to improve the symmetry of the tree. The trees are allowed to develop two or three main stems but branches are pruned if they interlock. The young plantations are given considerable shade and *Gliricidia* and *Erythrina lithosperma* (dadap) are considered best for the purpose. The *Gliricidia* is cut out after a few years but 40 to 50 dadap trees are left to each acre. For mature cacao heavy shade is considered harmful and the dadap trees are drastically pruned although in such a way that each tree affords light shade over as large an area as possible.

90. *Coffee*.—In Ceylon *Leucaena glauca* is considered to be the most satisfactory permanent shade tree as it does not give heavy shade nor does it require frequent pruning.

Tephrosia candida is sometimes used to provide temporary shade. The coffee plants are topped at five to six feet, and pruning is done as necessary after the crop season. It would appear that coffee required for seed purposes retains its viability for a much longer time if the pulp is removed soon after harvest; and I think that it would be well if all seed from Njala were sent out in parchment form, as in recent years there have been many failures which I attribute to the "heating" of fresh berries when packed in bags or closed boxes.

91. *Coconut*.—The coconut is a very important crop on the Malabar Coast, and when I was there I visited the Government Coconut Stations and Demonstration Plots. The Agricultural Department has four coconuts stations situated in and near Kasaragod on the coast of South Kanara. The farms are situated on different types of soil and are being utilized for cultural and manurial experiments and also as a source of good seed for distribution to farmers. The lessons to be learned from these farms appear to be that, when climatic conditions are favourable, the coconut requires, in addition, a fertile moist but well drained soil; sands and gravel soils are unsuitable although the coconut can be grown in such situations by very careful cultivation and very heavy applications of manure; the present low price of coconut products makes manuring an impossible luxury; selection of good seed from known parents is desirable; inter-cultivation is most beneficial and by this means alone yields can be considerably increased; inter-cultivation keeps down weeds and in the dry season has a mulching effect which preserves moisture and prevents the formation of surface roots.

92. With regard to the villagers' coconut trees these are usually found in the following situations: in the well manured soils of village gardens; in the well drained but moist lands just above the wet-land paddy fields; on the larger bunds between the paddy fields and along the alluvial banks of rivers. The seedlings are planted in well manured holes, and I noticed that it is quite usual to water the young trees during the dry seasons of the first three or four years. In low-lying situations surface planting is practised; and in very wet places the seedlings may even be planted on raised heaps. The villager's nursery methods are of interest and are as follows: a good parent tree close to the house, if possible, is selected and the nuts are allowed to remain on the tree until they are thoroughly ripe; after harvest the nuts are kept on a platform near the fireplace until they are thoroughly dry; after which they are soaked in water for two or three weeks. It is said that nuts treated in this way germinate in a very short time; the system is worth a trial in Sierra Leone.

93. Some years ago the Madras Agricultural Department set out to demonstrate that watering of young coconuts during the dry season is unnecessary and can be avoided by paying proper attention to cultural methods; not only has this been demonstrated, but it has also been shown that by adopting the same methods it is quite possible to grow coconuts in situations which were previously considered much too dry for this crop. The main secret of success is deep planting; strong healthy seedlings are planted in well manured holes, for which suitable dimensions are considered to be 4' x 4' x 4'; the hole is only filled to within two feet of the surface and the coconut seedling is planted at this depth; in the course of time the holes becomes filled up with manure and soil. The method is only suitable for dry or well drained situations; where there is ample soil moisture throughout the year ordinary surface planting will suffice.

94. With regard to coconut cultivation in Sierra Leone I feel certain that this will increase steadily, and although it may never become important from an export point of view, it can form a very useful addition to the local food supply. The cultivation of coconuts by the Protectorate native is quite a recent development, and, in the Northern Province at any rate, there are few if any trees over thirty years of age. At present most of the trees are to be found in the maritime villages and even there they are far from plentiful. I have noticed, however, that there is an increasing interest in this crop and that trees are appearing one by one in villages far inland. I receive constant demands for seedlings, but, in the past, transport difficulties have prevented me from getting much done: however, it is hoped to do more in the future, chiefly by showing those who can obtain nuts how best to make nurseries, and by establishing small plots, to serve as diffusion centres, in areas which are devoid of trees. I find that without assistance the average farmer finds it extremely difficult to raise coconut seedlings, and, although many are anxious to make nurseries, inexperience and past failures act as deterrents; this state of affairs can be remedied by the Agricultural Department.

95. The Kanarese system of drying and soaking the nut should be tried in Sierra Leone, as any method that will speed up the nursery stage will be welcome. Deep planting should also prove beneficial in situations which suffer from drought in the dry season. Inter-cultivation should be encouraged and in the early years of plantations inter-cropping will prove profitable.

96. *Cashew*.—This is a crop which appears to be worth cultivating more extensively in Sierra Leone as it will thrive in sandy and other poor soils which are unsuitable for most crops of economic value. The few trees that are already in the country appear to be healthy and quite prolific. I think it would be worth while encouraging the cultivation of this crop, especially in the Colony, with a view to finding a market for the nuts, first in Freetown and eventually in other countries. I understand that, in addition to the normal European demand, there is now an ever increasing market in the North American continent.

97. The cashew tree is much grown on sandy and other waste lands on the Malabar Coast and in recent years an important export trade, chiefly to the United States of America, has been developed, although there is also quite a remunerative local market. The grading and packing of the nuts for export require care but do not appear to be very difficult; the actual cultivation of the crop is simplicity itself. As a rule seed is sown at stake in waste lands, but transplanting from a nursery could of course be practised. A good planting distance is $15' \times 15'$. Once established the cashew is left to carry on in a semi-wild state; and no after cultivation is given, although bush growth, which is usually small on account of the poorness of the soil, may be cleared periodically.

98. The kernels are extracted in the following manner: the fleshy fruit stalks (cashew apple) having been removed, the cashew nuts (the true fruits) are placed in an iron pan and held over a hot fire until the tough outer shells are charred; this operation does not take long as the shells contain an acrid oil which is inflammable. This treatment makes the shell brittle and it is then possible to remove the kernel by placing the nut on a stone and cracking it with a stick. Broken kernels are set on one side and sold for poultry feed. The whole of this work is done by women and children. The pericarp oil, which I have mentioned, is used as a preservative for fishing lines.

99. *Casuarina*.—Within the last thirty years the planting of this tree, to provide fire-wood, has become popular in the coastal areas of the Kanara and Malabar Districts. The trees are chiefly owned by small holders and are usually found either in small plantation blocks or along the farm boundaries. The tree appears to thrive best in light loams but it also grows well in poor sandy soils.

100. The seedlings are invariably raised in nurseries. A loamy soil is considered best for the seed bed which is always well manured and thoroughly cultivated previous to sowing; the seed is sown thickly. Careful watering is essential. When the seedlings are six inches high they are planted out in nursery beds, where they remain until they are finally planted out, at which stage they are usually two to three feet high. Transplanting from seed to nursery bed is said to be beneficial as the operation encourages lateral root growth and retards the tap root; if the nursery bed stage is omitted it is found that long tap roots are developed which make it very difficult to transplant the seedlings when they attain a height of several feet; and attempts to do so result in many failures. Watering must be resorted to for some time if rain does not fall after the seedlings have been planted out. In the districts mentioned it is usual to fell the trees at ten to twelve years of age if the owners require a quick return; close planting is therefore practised; $6' \times 6'$ appears to be a good planting distance although $9' \times 9'$ or $12' \times 12'$ would be better if the trees can be left for upwards of fifteen years. The value for firewood of a twelve years old tree is said to be about 2s.

101. In Sierra Leone the destruction of bush is gradually leading to a shortage of fire-wood in some districts; and, in the course of years, this shortage is likely to prove very acute, more especially in Freetown and in the thickly populated maritime chiefdoms. At the moment mangrove wood is fairly plentiful in these areas but the mangrove forests, particularly the more accessible ones, are slowly disappearing and the possibility of growing casuarina for fuel should be kept in mind. It would, in my opinion, be a good plan to establish a few trees here and there in the coastal areas, for test purposes and as a source of seed if required.

102. *Jak and other Fruit Trees*.—I am confident that the Jak tree will thrive in all parts of Sierra Leone, and I recommend that its cultivation be encouraged. The local people may not care much for the fruit at first; but they will be quite keen to grow it, from pride of ownership if nothing else, and in time they will acquire a taste for it. I consider the encouragement of fruit growing most important; and, if jak, orange, breadfruit and avocado were planted more plentifully it would benefit the health of the people and also tend to lessen the area required for annual crops. My personal experience is that there is the greatest keenness to plant more fruit trees and I consider that the rate of progress could be greatly accelerated by supplying planting material, the lack of which is the chief bar to progress: this department can do much to remedy this state of affairs.

103. *Pepper*.—After his visit to Sierra Leone in 1929, Mr. H. C. Sampson recommended pepper as a possible export crop; and in the following year he sent some plants from Kew: these plants are now at Njala where they appear to be thriving satisfactorily. When I was on the Malabar Coast I visited the Government pepper station at Taliparamba and also inspected many private gardens in different parts of Malabar. The conditions which are considered suitable for pepper in Malabar can be found in parts of Sierra Leone; and, if

the farmers have sufficient patience to learn the cultural treatment which it requires, it should be possible to grow this crop satisfactorily, although it will take time to establish any considerable quantity of it as propagation is slow and somewhat tedious.

104. On the West Coast, pepper is found in practically all gardens, where it grows under the shade afforded by mango, jak, arecanut, and other fruit trees; similar conditions are to be found in Sierra Leone in nearly all villages in the southern half of Sierra Leone. The best pepper comes however from the pepper gardens in the foot-hills of the western ghats where the crop is grown on the lower valley slopes and on the lower slopes of the actual ghats; conditions which are practically identical are to be found in Sierra Leone in the Bonkalenken and Kuniki Chiefdoms of the Northern Province and also no doubt along the base of the plateau area in the Kono District of the Southern Province.

105. Pepper appears to occur up to rather over 3,000 feet, but it is at its best below 2,000 feet. As regards soil, pepper does best in red laterite soils recently cleared of forests; although, both in India and Ceylon, it appears also to do fairly well in alluvial soils if these are not subject to flooding. Pepper cannot withstand severe drought, and soils must therefore be retentive of moisture in addition to being well drained. Pepper should not be planted on slopes with a southerly aspect. In Ceylon the pepper crop receives a rainfall of 80 to 100 inches but on the Malabar Coast the rainfall is heavier and averages about 140 inches.

106. Pepper requires shade and a standard to climb up, and it is customary to make one tree serve both purposes. Living standards are invariably used. In selecting a tree for the purpose it should be remembered that the requirements are a quick-growing rough-barked tree with a deep-root system; and, in addition, it should be able to stand up to heavy pruning. In Malabar, *Erythrina indica* is the favourite standard. In Ceylon it is quite a common practice to grow pepper on the shade standards in cacao plantations.

107. Pepper is usually propagated by cuttings, as seed germinates very slowly and unevenly. In Ceylon the cuttings are placed in nurseries, and those that strike are transferred to baskets. In Malabar the cuttings are placed at once in trenches at the foot of the standards. The trench, which is made with a narrow long-bladed hoe, is usually twelve to eighteen inches deep and about four inches wide, and is always dug on the north side of the standard. The best cuttings are obtained from the runners which come out at the base of the vine; but top cuttings are sometimes used. As runners very readily strike root at their nodes it is usual to place small forked sticks at the base of each vine and as each runner grows it is kept clear of the ground by coiling it around one of these sticks. These runners make their appearance when the vines "flush" at the commencement of the rains: by the following rainy season they are ready for planting; and this is done by taking cuttings, with five or six nodes, and planting them, five or six together, in the trenches I have mentioned. Half the cutting should be below the soil surface and the protruding parts should be shaded with leafy twigs. The percentage of cuttings that strike is very low and frequent replacements are necessary. As the cuttings grow they must be carefully tied to the standard.

108. The standards, which are sometimes bush trees left when the forest is cleared, should be about ten feet apart. The intervening spaces should be clear of vegetation. Fairly heavy shade is required during the first four or five years, but once the vines come into bearing the shade must be reduced as heavy shade lowers the yield very considerably; accordingly the standards should be judiciously lopped at the commencement of each rainy season.

109. As pepper plantations are usually made on newly cleared forest land or rich garden soil it is seldom necessary to resort to manuring if soil erosion can be prevented. It is however good practice periodically to heap some rich soil around the base of each vine.

110. If the vines tend to grow tall and thin with few side branches, it is found advantageous to remove the vine from the standard and coil it in a hole dug near its root. Only the tips of the vine and its runners are left above ground. This operation, which is done early in the rainy season, encourages the growth of lateral branches.

111. Berries are harvested when they turn red in colour. Immediately after picking they are removed from the spike and separated from the trash by winnowing. The berries are then steeped in boiling water for ten minutes after which they are dried in the sun for three or four days. This is the treatment when black pepper is required. To produce white pepper which consists of the decorticated berries, the procedure is as follows: the ripe berries

are kept in a moist heap for two or three days; this softens the pulpy pericarp which is then removed by trampling under foot. The decorticated berries are then washed in baskets and spread out to dry.

ANNUAL CROPS.

112. *Millets*.—It is probable that some of the lesser millets, more especially *Eleusine coracana*, *Panicum miliare* and *Setaria italica*, will thrive in Sierra Leone and I therefore obtained selections for trial. These millets will not interest farmers in bush areas where rice is plentiful, but in the grass and orchard bush tracts of the Northern Province they may be appreciated. These millets can be grown exactly in the manner of *Digitaria*, but whether the native will consider them as palatable remains to be seen.

113. *Eleusine coracana* is likely to prove particularly useful; as, in addition to thriving on dry uplands, it can also be grown in fairly damp situations. In India it is very commonly raised in nurseries, and transplanted in irrigated lands. This crop may be suitable for cultivation in swamp lands during the dry season. In addition, it withstands quite a high degree of salinity, and, on this account, it might find favour as a catch crop in certain parts of the Delta lands where the poorer classes would probably be glad to grow it.

114. *Benniseed*.—In the Tanjore Delta *Sesamum indicum* sometimes follows rice. The variety used is of three months duration; the seed is sown broadcast while the land is still moist; subsequently the crop may receive a few irrigations although frequently it has to depend entirely on a few irregular showers. I believe benniseed could be successfully grown in Sierra Leone in many wet lands during the dry season. As benniseed is a very valuable food crop as well as a useful money crop, the introduction of a quick maturing variety for sowing at the end of the rains may prove advantageous.

115. *Sunn-hemp*.—In the areas visited by me sunn-hemp is chiefly used as a green manure crop for wet lands, and for this purpose it follows the rice crop. In Sierra Leone the farmer will not at present grow green manure crops but it seems possible that sunn-hemp could be grown as a fibre plant in the drier uplands of the plateau area, and during the dry season, in the double crop areas of the Deltas. I am not very hopeful of success but I think it is worth trying. If it can be grown in the Deltas there will be quite a good local demand for the fibre for making into fishing nets and lines.

116. *Miscellaneous*.—Other crops, concerning which I gained some experience, were tobacco, sugar cane, and cotton, but as this information does not appear to be of any immediate interest to us in Sierra Leone I have omitted it from this report.

CATTLE.

117. I had excellent opportunities of studying the various breeds of cattle, including buffalo, in South India, and the different purposes for which they are used; but the insertion of general descriptions and explanations is out of place in this report and is therefore omitted. I consider that the breed of cattle now in Sierra Leone is adequate for our immediate needs and capable of satisfactory ploughing in wet lands as well as on upland farms. With regard to the use of oxen for road transport I think this is worth a trial although the venture may be slightly premature. Now that the road system links up so many areas with the railway there must be many large farmers and native traders who could profitably adopt this form of transport. The local oxen should be quite suitable for road work, although heavier, humped animals would of course be better. Apart from the natives' conservatism there are two other difficulties to surmount, namely the manufacture of carts and the shoeing of the animals. For this reason it may be some time before anything can be done but in the meantime it is worth testing the feasibility of using oxen as pack animals on the better non-motorable roads.

TILLAGE.

118. On account of our present effort to establish ploughing in Sierra Leone I was particularly interested in tillage methods and implements in South India. I not only saw all the important indigenous implements at work but also the introduced implements which the Agricultural Departments are testing as being possible improvements. In Madras I received useful information from the Agricultural Research Engineer who demonstrated the merits and defects of a wide range of ploughs. It is of interest to consider the position in India, with a view to determining which, if any, methods and implements can be usefully tried in Sierra Leone.

119. *Wet-land Cultivation.*—It is usual to work wet lands while they are in a flooded condition. The ordinary procedure, as already described, is to use the wooden plough followed by the different levellers: but where the soil is a deep soft mud, it may not be possible to plough; and cultivation, if any, is done with a long-handled, broad-bladed hoe. In Ceylon, wet lands are sometimes puddled by driving teams of buffalo around the flooded fields.

120. Where flooding is deep and not controllable it is customary to plough the land as soon as the floods subside in the dry season; ploughing leaves the fields in a very rough condition as the clods are hard and do not weather easily. In some cases the land is left in this condition until the first signs of returning floods, when the fields are ploughed wet, and the rice transplanted from nurseries. In most cases, however, the farmer prefers to broadcast the seed when using lands of this type; and it is therefore necessary to obtain a good tilth by dry cultivation, which consists of breaking down the clods, by using wooden harrows, or by beating them with long-handled mallets; these operations, which are followed by further ploughings, are carried out just previous to the break of the South-west monsoon.

121. *Upland Cultivation.*—Here again the wooden plough is used, although in Central and Northern India iron ploughs are frequently used with advantage. In friable soils a fine tilth is obtained by repeated ploughings in the dry season; eight to twelve ploughings is not unusual on the West Coast. In heavier soils the first ploughing is given soon after harvesting and leaves the field in a very rough state. A certain amount of weathering takes place during the dry weather; and on the approach of the rainy season a seed bed is prepared by harrowing for which the heavy “guntaka” is suitable, and by further ploughing.

122. *Indigenous Implements—Ploughs.*—The general appearance of the indigenous wooden plough is too well known to merit description. It is always used with a pole; and, when used for upland work, the projecting front of the body is protected by an iron point.

123. *Harrows.*—As inverting ploughs are seldom used, harrows are only necessary for heavy soils, which cannot be reduced to a fine tilth by weathering and the use of the wooden plough alone. In lands which are worked wet, the plough is followed by buffalo or bullock-drawn levellers which break down any remaining lumps. The commonest type of leveller consists of a thick plank similar in size and shape to a wooden railway sleeper. One end of the pole by which the levelling board is drawn is inserted on the top of the board and in the same line as it, so that when in operation the angle of the board with the ground is about 30°. In Ceylon a leveller made of a round log is often used to give a final smoothing to fields in which rice is sown broadcast. In dry lands, as already mentioned, the heavy “guntaka” or blade harrow is used and is very effective. There are several types of “guntaka” as the implement is used for various purposes, but the heavy one, used primarily for harrowing, consists essentially of a heavy eight-sided beam fitted with an iron blade which projects in front and below the beam. This blade moves through the soil just below the surface and cultivates it; and the beam, which rides just on the surface rolls along and disintegrates any lumps left by the blade.

124. *Introduced Implements.*—Although the wooden plough gives excellent results in wet lands, there is no doubt that for upland cultivation an iron inverting plough is much superior, and the Madras Agricultural Department is now endeavouring to encourage the farmers to use the iron implement. Apart from his innate conservatism, the farmer has the following objections to the iron plough: high cost, not suitable for wet-land cultivation as it does not score or form puddle so well, difficulties of effecting repairs and replacements, and change in technique necessitated by its unsymmetry. In favour of the iron plough is its durability and the better work done by it in all but wet lands, although, even there, a suitable iron plough would appear to be superior for the initial ploughings, as it is chiefly in the formation of puddle that the wooden plough excels. However, it must be admitted that the purchase of an iron plough involves an initial outlay which is prohibitive for many farmers; and until implements can be manufactured locally at a considerably cheaper rate than the imported English and American ploughs much progress cannot take place. Messrs. Cooper of Satara, Bombay, are now endeavouring to make cheaper models of some of the most popular imported ploughs; and, although the results have not been quite satisfactory so far, it would appear that they will succeed in the near future.

125. In recent years the Madras Agricultural Department have experimented with a wide range of modern ploughs; and, as a result of their experience, it is now possible to point to half-a-dozen ploughs as being particularly suitable for the ordinary farmer. The following descriptions refer to these ploughs; the prices given are the selling prices in Madras:—

Plough.	Maker.	Price.	Particulars.
Victory ...	Ransome	Rs. 42. ...	Excellent general purpose plough. Strong and well balanced-steel mould-board and share. Two-handled beam plough. Draught, two good oxen.
Monsoon ...	Ransome	Rs. 19. ...	Good general purpose plough. Fitted with one or two handles and can be used as pole or beam plough. Body and mould-board cast in piece; share alone steel. Renewable point, which should be all chilled. Draught, rather less than "Victory."
New Bantam	John Deere, Moline, U. S. A.	Rs. 18. ...	Excellent general purpose plough. Steel mould-board and share. Two-handled beam plough. Shares 7", 8", 9", 10". Draught same as "Victory."
Chattanooga 62 (sometimes known as "Hindustan".)	Imperial Harvesting Company	Rs. 14. ...	Excellent general purpose plough. Two-handled beam plough. All chilled mould-board and share. Share has renewable point. Draught same as "Monsoon."
Hindustan	Avery, U. S. A.	Rs. 13. ...	Excellent small general purpose pole plough, with one or two handles. Steel mould-board and share. Excellent in wet-lands and on upland farms if deep ploughing not required. Draught two small animals.
Meston	Howards Ransome	Rs. 8. ...	One-handled pole plough with steel mould-board and chilled share satisfactory in wet-lands. Draught: two small animals.

126. Brief mention may be made of the Burmese harrow which has been introduced into Ceylon for trial in connection with wet-land paddy cultivation. The Burmese harrow consists essentially of a heavy log with five or six wooden tines. It is used in the same way as the levelling board but in addition it stirs the soil to a considerable depth. It is an efficient and cheap implement but I consider the draught too heavy for a pair of Sierra Leone oxen.

SIERRA LEONE.

127. Since my visit to India I am confident that, in addition to upland ploughing, wet-land ploughing in connection with rice cultivation is a practical proposition in Sierra Leone, and can be undertaken with certain slight modifications, which may prove necessary as bunding and water control are not practised in Sierra Leone. My suggestions with regard to the improvement and extension of ploughing are as follows:—

128. *Upland Farms*.—Plough, after harvest, in October to December. Cross-plough in March to May when the first showers soften the ground, and follow with the harrow to give a good tilth. Use a zig-zag harrow if available but otherwise an improvised log or brush-wood harrow must suffice. An effective harrow, known as the triangular or Sampson's harrow may be cheaply made by inserting tines along the three sides of a heavy, wooden, triangular frame. A "guntaka" might prove satisfactory and is worth trying. The seed should be covered with a harrow. These are the methods we are now demonstrating; but I find that there is a tendency for most farmers to postpone ploughing until the ground becomes very hard, and in addition many of them are inclined to belittle the importance of a good tilth.

129. So far in Sierra Leone we have chiefly concentrated on Ransomes' "Victory" plough; although in the beginning we tried several French ploughs, but these, although fairly satisfactory, did not prove as good as the "Victory." The "Victory" has given excellent results, but it is expensive and I am in favour of introducing a cheaper plough which will be within the reach of the small farmer. I consider that the Imperial Harvesting Company's "Chattanooga" 62' may suit us very well; the price is reasonable, the draught is suitable, and, in addition, the mould-board is chilled so that it will score better and last longer when used in sandy and gritty soils than the steel mould-board of the "Victory." Moreover, the "Chattanooga" share has a renewable point which is a desirable feature; the "Victory" share is steel and all in one piece; and, as a result, the point wears away very quickly, and since there is no spare metal which could be beaten out into a new point, complete new shares are required fairly frequently. Avey's "Hindustan" is another excellent plough which merits a trial in Sierra Leone—although it is unfortunate that it is not a British product—as it is cheap and efficient; it is however a pole plough and may not work well with our present system of yoking. I obtained one of these ploughs in Madras and hope to test it at the first opportunity. John Deere's "New Bantam" and Ransomes' "Monsoon" are also suitable ploughs for trial, but I prefer the "Victory," Avey's "Hindustan," and "Chattanooga," 62'.

130. *Wet lands*.—In Sierra Leone ploughing has so far been confined to upland areas, and to river flats which, although swampy in the rainy season, can be worked in the manner of upland cultivation during the dry season. The results obtained in these swampy alluvial lands have been only moderate; the production of a good tilth has given much trouble, and it is evident that in future the large hard clods which the plough leaves in this type of land must be broken down with heavy harrows. Mr. Sampson has recommended the use of an improvised harrow consisting of two heavy parallel logs joined with short cross sticks; the whole being in the form of a ladder. The flooding of these areas is so irregular in the manner and time of its commencement that the raising of seedlings in nurseries, for subsequent transplanting, would appear to be impracticable; and, this being so, wet ploughing is not likely to be of value; the feasibility of doing so should however be investigated by actual trial.

131. So far no ploughing has been done under proper wet-land condition, although rice is so widely planted in swamps where these conditions are normal. Trials are desirable as soon as possible. I feel sure that it can be successfully and profitably done. Our oxen are suitable although they may not take kindly to the work at first. With regard to a suitable plough for wet-land work I recommend Avey's "Hindustan," although the "Meston" is also worth trying. Both are pole ploughs, and this type of plough seems to be more suitable for wet-land work than the short beam-plough. As mentioned already, I am not sure whether our present yoking system can be used with pole ploughs; I am inclined to think it is unsuitable and, if so, a new yoking arrangement must be devised.

132. I do not recommend the introduction, even for wet lands, of the wooden ploughs as I think we shall get on better with a suitable iron plough for the preliminary cultivation and an implement similar to a small Burmese harrow to do the final puddling.

IRRIGATION.

133. In Sierra Leone watering by hand is the only type of irrigation known, but even this is not much practised. The explanation is that, although there is a long dry season yet on account of the cheapness of agricultural land and the abundant rain in the wet season, it is possible for the farmer to raise an ample food supply during the rainy season alone: when land becomes scarce more intensive agriculture will, of necessity, be practised, and irrigation will be adopted in order to prolong the planting period over the dry season. To-day the only kind of controlled irrigation is by sprinkling from basins and calabashes, by which method vegetables are grown in the dry season in parts of the Colony as well as in several chiefdoms in the Protectorate. In the Biriwa Chiefdom

of the Northern Province dry season gardens are made close to streams, and the following, among other crops, are grown: tobacco, maize, okra, ground-nut, spinach, and capsicum. In the Bullom Chiefdom, vegetables, chiefly tomato, capsicum, okra, onion, maize and spinach, are grown for the Freetown market. In the Koinadugu District tobacco is grown, in the dry season, in the valley bottoms. In the Bullom Chiefdom shallow surface wells are dug in the garden lands, which are low-lying, and the water is lifted bucketful by bucketful and applied by hand sprinkling; in the other areas the method of application is the same but the water is taken from a nearby stream. The use of any kind of water-lift is unknown nor is water ever distributed by gravity from diverted streams.

134. In India and Ceylon all types of irrigation systems were seen; the simplest of these are here described briefly, as sooner or later they can be usefully employed in Sierra Leone. I have not attempted to describe the details of all the working parts of the various water lifts, but I can supply photographs and fuller information if anyone wishes for further information. The elaborate irrigation system of the larger Indian rivers and of the "tanks" of Ceylon have no practical application in Sierra Leone and I do not refer to them further.

IRRIGATION SYSTEMS.

135. *Irrigation by direct Rainfall.*—I have already described how wet-land rice is grown on the Malabar Coast and in Ceylon by impounding the direct rainfall and surface flood water in bunded fields in the bottoms and on the lower slopes of the valleys. By this system it is possible, in a country with a rainfall like that of Sierra Leone, to raise at least one crop of wet-land rice in the rainy season.

136. *Irrigation from Streams and Rivers.*—I have also referred to this method which is practised on the Malabar Coast. Where perennial streams occur, a crop can be raised in the dry season, either by damming the stream until it overflows into channels on the banks or by using a water-lift. When the lie of the land is not too flat it is often possible to divert part of a stream at a higher point in its course and conduct it along a flatter gradient, by which means the intervening area can be irrigated by gravity.

137. *Well Irrigation.*—On the Malabar Coast, where there is a long rainy season, wells are only used to supply the irrigation water for the dry season crop which may be the third crop from the same land in the same year. In areas with a medium rainfall, well irrigation may be supplementary to channel irrigation; whereas in the Jaffna Peninsula of Ceylon, and in similar areas—with low rainfall and no surface water supplies—in South India, wells are the sole source of irrigation water.

138. *Tidal Irrigation.*—In Appendix II I have described how the waters banked up by tidal action are utilised for the irrigation of rice on the marginal lands of river estuaries.

APPLICATION OF IRRIGATION WATER.

139. Apart from irrigation by sprinkling, which is rarely used in India except in betel gardens and for nursery work, there are two common methods of applying irrigation water, no matter what its source; namely, flood irrigation and furrow irrigation.

140. *Flood Irrigation.*—This method, which consists of delivering the water at one point and allowing it to spread evenly over the whole field by gravitation, is the commonest way and is invariably used for rice, both nurseries and farms. The method is very simple but the land must be very level: in uneven country the fields are of necessity very small; in the Delta lands of the East Coast the individual fields are often over half an acre in area, but on hill slopes a field may be only a few square yards in extent. When the source of supply is direct rainfall and surface flood water it is often impossible to control the supply to any extent, and excess water is often merely allowed to flow from one field to the next; although, in areas where there is a heavy rainfall and a big drop in level between the fields, the surplus flood water must, if possible, be prevented from running through the fields, as this may cause serious scour, and should instead be confined to special channels or natural streams.

141. As irrigation water is valuable especially when raised from streams or wells, it is important that there should be as little waste as possible; and, for ease and efficiency in handling it, the bunded fields are divided into beds in which the water is impounded by low temporary bunds. The size of the beds depends on the lie of the land, but for garden crops and transplanted *Eleusine* an area of about 100 square feet is considered suitable: the water may be allowed to flow from bed to bed; but, in level land, it is more usual to make the beds in parallel rows with an irrigation channel between every two rows of beds, the water being diverted to either side as requisite. The chief disadvantage of flood irrigation is that the surface soil cakes very readily.

142. *Furrow Irrigation*.—In furrow irrigation the water is confined to the furrows between the parallel ridges on which the crop is grown. The furrows may lie along the slope of the land, in which case the water enters each furrow separately from the supply channel; or the furrows may lie across the slope, in which case the water takes a zig-zag course down the bed, rounding the opposite ends of each alternate ridge. More frequently however irrigation is a modified form of flood irrigation; the water being delivered at one point, from which it finds its way into the furrows from either or both ends. Theoretically, furrow irrigation is more efficient than flood irrigation as there is less evaporation and less caking of the surface soil; in addition there is little danger of over-irrigation. The laying out of the land requires more skill however, and, for this reason, flood irrigation is more commonly practised.

WATER-LIFTS.

143. There is no need to refer to the use of pumps for raising irrigation water as only the simplest cheapest methods are likely to find favour in Sierra Leone. The following are the commonest methods of raising water with animal and manual labour.

144. *Lifts operated by Animal Power*.—The Persian Wheel, and the Single and Double Mhotes are extensively used for raising water from wells; in each case the motive power is a pair of oxen. I describe these lifts very briefly as I do not consider that any of them can be usefully introduced into Sierra Leone at present.

145. *Persian Wheel*.—Consists of a large wheel with an endless chain of buckets which are kept in motion and alternately filled and emptied by bullock driven gear. The animals walk round the well and move continuously in the same direction. This lift is very efficient for wells not more than 20 feet below the surface; if the depth is greater than this the weight of the water in the buckets becomes excessive.

146. *Single Mhote*.—This consists of an arrangement whereby a mhote (bucket) is alternatively raised and lowered, over a pulley fixed above the well, by means of ropes attached directly to the oxen's yoke. The oxen walk down an incline of about one in five when drawing up the full bucket; and they back up the incline to lower the empty bucket. The bucket, which may be made of wood or metal, is hemispherical and is fitted with a leather or canvas tail (about 4 feet long). The manner of emptying the bucket is very ingenious: when the bucket is being raised, the tail, which is in the form of a tube, is doubled back on itself, with its open end above the top of the bucket; but when the latter rises above the surface of the well the tail is automatically drawn towards the irrigation trough into which the water is rapidly discharged. This lift is suitable for depths of ten to thirty feet.

147. *Double Mhote*.—The principle is much the same as in the single mhote, and the bucket is worked in exactly the same manner. The incline is however steeper, being as much as one in three; and the animals do not back up it on the return journey, but instead they return to the top by a path at the side. When unhitched from the yoke, the bucket descends into the well by its own weight, at the same time assisting the driver, who holds on to the rope, to turn to the top of the incline. Having reached there he attaches the rope to a second pair of oxen; two pairs being generally employed to avoid unnecessary delay.

148. *Stoneys' Mhote*.—In this mhote two self-tilting metal buckets alternatively ascend and descend on guide rails fixed to the side of the well. The oxen work the gear by walking round in a circle (but not round the well). The advantages of this type of mhote are three: the weights of the buckets counter-balance each other; movement of the oxen is unbroken; and the output is greater than in any other mhote. It should be noted however, that the force of gravity, acting through the medium of the animals' weights, is not utilized to the same advantage as is the case when the oxen work on an inclined plane.

149. *Lifts worked by Manual Labour*.—Many types of water-lifts worked by manual labour were studied, and I am of the opinion that the simplest of these may prove useful in Sierra Leone.

150. *Picottah*.—The picottah, or well sweep, is a most efficient water-lift; but I cannot advocate its adoption in Sierra Leone until simple methods have been tried, as it is likely to prove much too dangerous for Africans who have not had previous experience of this kind of work. The water is raised in a bucket which is attached, by a suitably long rope or bamboo pole, to one end of an oscillating beam, the motive power for which is provided by men who walk up and down on it, and by the correct distribution of their weights on the lever, cause the bucket to move up and down. A rough scaffolding at one side serves as a balustrade for the workers on the beam. One man guides the bucket in the well, and tilts the water into the irrigation trough when the bucket comes to the top. According to the size of the sweep, one to four men are required to work on the beam. This type of lift can be modified to suit depths of five to twenty feet.

151. *Kanarese Picottah*.—On the banks of the Netravati River, near Mangalore, I saw an unusual but very simple well sweep which appeared to be efficient for lifts of six to eight feet. There is the usual oscillating beam; in this case with equal arms and with the weight of the empty bucket counter-balanced by an equal weight on the other end of the beam—the whole system being in a state of equilibrium. One operator, as usual, is necessary to guide the bucket in the well and to empty it into the trough when it comes to the surface. The full bucket containing from four to eight gallons, is raised by suspended weight of two persons—usually women—who swing from ropes attached to the weighted end of the beam. When the bucket has been filled, the women swing themselves down into a shallow pit, taking care to hold the ropes at such a point that their fall will raise the bucket to the correct height—the level of the trough. When the bucket has been emptied, the women return to the starting point by an incline leading out of the pit.

152. *Counterpoise Lift*.—This is a simple, efficient and easily constructed lift for working wells not deeper than twelve feet. It can be worked by one man. There is the usual oscillating beam but in this case the arms are of different lengths. The bucket is attached to a bamboo pole fastened to the end of the long arms; while to the end of the short arm is attached a weight sufficiently heavy to produce a state of equilibrium in the system when the bucket is full of water. The operator, working with gravity, pulls the bucket down into the water by an arm over arm action, as he stands—on a platform at the top of the well—holding the bamboo pole to which the bucket is attached. When the bucket is full it is drawn up by the counterpoised weight on the short arm. The ratio of the length of the short to long arm should be about one to two or two-and-a-half. The bucket, which is best made of iron, holds about three gallons, and is fastened to the end of the bamboo pole by a pin in such a way that it can be tilted to facilitate filling and emptying. This type of lift can of course be satisfactorily used for quite small distances, although for raising water through distances of less than three feet, especially if from streams and channels on to the marginal land, it is customary to use one of the following four lifts:

153. *Archimedian Screw*.—Consists of a wooden cylinder containing a spiral wooden partition which being rotated by a handle at the top screws the water upwards; the cylinder is fixed at a slant with one end below the surface of the water to be lifted.

154. *Trough Lift*.—Consists essentially of a trough (six to ten feet) open at one end and a counterpoised beam, the unweighted end of which is attached by ropes to the closed end of the trough. The open end of the trough is placed on the edge of the bank on to which water is to be lifted and the other end is alternately lowered and raised. The trough is filled by the operator stepping on it until it is submersed, the counterpoised weight lifting and emptying the trough when he removes his weight. The trough may be made of metal, but usually it consists of a hollowed-out trunk of the *Borassus* palm.

155. *Swing Basket*.—Suitable for short lifts of one to three feet, and commonly used in places where a more permanent form of lift is not required. Two men, facing each other at a distance of about six feet, hold in their hands a pair of ropes—one fixed to the top and the other to the bottom of the basket—and by a swinging motion and a clever manipulation of the ropes water is taken up and thrown on to the higher level. A closely woven basket is generally used, but a light metal bucket can be used. The bulk of the work is done by the muscles of the back, and not those of the arms.

156. *Malabar Shovel*.—In Malabar this very simple lift is used for raising water through small heights of up to two feet. This lift consist of a big long-handled wooden shovel which is suspended from a tripod by a rope which reaches within eighteen inches of the water surface; the rope takes the weight of the water and the operator simply swing the shovel backwards and forwards; the point of the shovel describes an arc of a circle and the water picked up at the bottom of the swing is thrown out at its completion.

PROSPECTS FOR IRRIGATION IN SIERRA LEONE.

DELTA LANDS.

157. *Main Tidal Rice Areas*.—Controlled irrigation of the main delta rice lands is unnecessary at present as the farmers get excellent crops with the natural tidal irrigation.

158. *Tidal Salt-affected Lands*.—Where there is good drainage and adjacent uplands, salt-affected lands may be made available for rice cultivation, by erecting bunds to keep back the tidal salt water and to hold up fresh water, resulting from direct rainfall and the seepage and “run-off” from the uplands.

159. *Occasionally-tidal Lands*.—The rice farms in these lands become very weedy, and it is believed that judicious bunding would make it possible to control weeds and improve the crop yield by maintaining a suitable depth of water. In areas which are salt-free, vegetable gardening in the dry season may be possible by irrigating from surface wells or from the river itself: for raising water the counterpoise lift is recommended.

VALLEY LANDS.

160. *Valley Bottoms*.—In most valley bottoms utilized for rice cultivation the use of bunds will prove most beneficial by ensuring a better and more uniform depth of water and by preventing soil erosion; the latter is quite severe in many of the valleys in the mountainous part of Sierra Leone, so much so indeed that very often the rice crop cannot be transplanted but must be sown broadcast in order that it may become established before the heavy rains commence.

161. Where a perennial stream occurs, the rice crop may be followed by tobacco and garden crops, irrigated by gravity from channels or by raising water direct from the stream by means of a counterpoise lift, through lift, swing basket, or Malabar shovel. Where there is not a perennial supply of surface water, the rice crop may be suitably followed by sweet potato, as is often done at present; although, occasionally, it may be possible to obtain sufficient water from temporary surface wells to enable garden crops to be grown under irrigation.

162. *Valley Slopes*.—Where valleys are permanently cultivated the slopes immediately above the normal wet-land area can be profitably levelled and bunded. In the rainy season a rice crop can be raised by conserving direct rainfall and the surface flood water from the higher lands; the rice crop can be succeeded by sweet potato. This method was successfully demonstrated at Makump in 1931 by Dr. Martin, who also showed that a perennial stream could be easily diverted, along a flatter gradient, by damming, and its water used as requisite to irrigate garden crops or a second crop of rice.

163. It is realized that irrigation, other than hand watering, is quite foreign to existing agricultural practice, and that farmers are not likely to change their methods easily. I consider however that there are distinct possibilities for simple irrigation in the immediate future, especially for tobacco and garden crops in the Northern Province where many valleys are intensively cultivated every year.

IV.—SUMMARY.

164. The object of my visits was primarily the study of rice cultivation, paying particular attention to the breeding work being done in connection with this crop by the Agricultural Departments of Ceylon and Madras. I landed at Bombay on 3rd April and sailed from Colombo on 29th July; during the interim I visited the greater part of Ceylon and the west and east coasts of Madras. I also spent a considerable time at Coimbatore which is the central Agricultural Research Station for the Madras Presidency. The rice crop had, with a few isolated exceptions, been harvested but I had excellent opportunities of studying tillage, manuring, nursery work, transplanting, water-control and the lay-out of the fields.

RICE.

165. Cultural methods and the varying conditions under which the crop is grown are described, particular attention being paid to the methods used on the West Coast of Madras as soil and climate conditions there closely resemble those of Sierra Leone. The work of the Agricultural Departments to improve the rice crop is referred to and the technique of pure-line selection breeding is described in detail. Methods of extending the normal wet-land areas and of utilizing deep-water and saline lands are described. With regard to improving rice cultivation in Sierra Leone the following recommendations are made.

166. *Delta Lands*.—As soon as money is available the establishment of a rice station in the Scarries area is recommended; the primary work of this station would be to provide improved seed of good varieties and to carry out cultural investigations. The supervision of the station and itinerant work in the surrounding districts will probably entail the whole-time services of an Agricultural Officer. In the immediate future it is recommended that the present staff should as far as possible make themselves familiar with existing conditions and methods. The more intelligent farmers should be taught to improve their seed by mass selection. With regard to nursery work, more thorough cultivation and a lower seed rate are recommended; and in the case of farm operations the following are considered possible improvements: plant economically—not more than three seedlings to the stand; in weedy lands cultivate with hoe and use plough if possible; drain salt affected areas and make bunds if necessary; experiment with special varieties of rice in saline, deeply-flooded, and double-crop lands; in this connection I obtained seed which may prove useful.

167. *Inland Swamps*.—At a future date the establishment of a rice station in the hinterland is also recommended, as the fullest development of inland valley lands is of the greatest importance as a step towards the reduction of the area devoted to shifting cultivation.

The work of this station would be similar to that of the station in the delta, but particular attention would be paid to bunding and water-control, and to the cultivation of crops other than rice in the dry season. Where valley bottoms are permanently cultivated the extension of the normal wet-land area by levelling and bunding is worth attempting.

168. *Milling*.—The rice milling industry of the East Coast of Madras is referred to and the desirability of introducing rice-cleaning machinery into Sierra Leone is considered. Milling for local supply, and for export in case of surplus, is recommended, and suitable centres for mills are suggested. The early establishment of a mill in the delta rice lands is considered desirable.

GENERAL AGRICULTURE.

169. In addition to studying rice cultivation I made use, so far as time permitted, of the excellent opportunities that I had for studying all the important crops of Ceylon and Madras. Agriculture on the West Coast of India is described and is recommended as a model for development in Sierra Leone; its adoption would result in an increased area under wet-land rice; a reduction in shifting cultivation; an increase in the area under fruit trees and garden crops; the reservation of bush areas for leaf-manure, timber and fire-wood; and the extensive use of cattle for ploughing and transport.

170. Cashew, Casuarina, Pepper, Jak, *Eleusine coracana*, *Panicum miliare* are considered to be possible crops for Sierra Leone and their cultivation is described in some detail. Some notes on cacao, coffee, and coconut cultivation are given.

171. The use of cattle for transport and ploughing is considered, and it is recommended that wet-land ploughing should now be essayed in Sierra Leone. Tillage methods and implements are described and those suitable for Sierra Leone are mentioned.

172. Irrigation methods and different types of water-lifts are described and the prospects for irrigation in Sierra Leone are considered.

APPENDIXES.

I—ITINERARY.

April 3—Bombay.

April 5—Madras.

April 7 to 9—Colombo.

April 10 to 15—Peradeniya.—Experimental Station, Paddy Station, Botanic Gardens and all laboratories. Cacao and tobacco in the Dumbara Valley. The “Yala” season had just begun and I saw the preparation of the rice fields and seed being sown.

April 16—Colombo.

April 17 to 23—On tour in the Southern Division, accompanied by the Agricultural Officer. Visited the following Agricultural stations:—

Batapola: Paddy seed farm.

Labuduwa: General.

Wirakitiya: Chillies Station.

Tissamaharama: Paddy and Cotton Station.

Batata: General.

Welegama: Paddy.

Meddeniya: General.

Visited tea and rubber estates at Elpitiya and many villagers' farms.

April 24 to 28—Peradeniya.—General. Visited rice areas in neighbourhood with the Economic Botanist and also made short excursions with the Agricultural Officer and the Systematic Botanist. Visited tea and rubber estates at Hindugalla. The “chena” system of farming is widely practised in this Division. Noted system of coconut cultivation.

April 29—Left on tour with the Economic Botanist and the Agricultural Officer of the Central Division. Nalanda: General Agricultural Station. Pelwehera: rotations with upland crops.

April 30—Anuradhapura: General and Paddy stations.

May 1 to 4—With the Economic Botanist and the Agricultural Officer for the Northern Division I visited the following stations:—

Vavunia: General and Paddy seed farm.

Paranthan: Experimental Paddy Station for the dry zone.

Tirunenvelli: General Experimental Station for the Jaffa Peninsula.

May 5—Talaimannar.

May 6—Left Ceylon.

May 7 to 8—Madras, where I discussed my itinerary with the Director of Agriculture.

May 9 to 13—Coimbatore. Here is the Agricultural College and the Central Agricultural Station, and here the Research Specialists have their laboratories and experimental farms. I spent most of my time making myself familiar with the rice work but I also became acquainted with the most important aspects of the field and laboratory work being done in connection with cotton, millets and sugar-cane. I studied methods of cultivation, manuring and irrigation, and other matters relating to general farm management. The rainfall of this area is only about twenty-five inches and consequently most crops are grown under irrigation. At this time irrigation water was not yet available as the monsoon had not set in and there were few standing crops to be seen.

May 14 to 28—Malabar and South Kanara on the West Coast. This area has a heavy rainfall, averaging about 150 inches. The South-west monsoon had not commenced but was expected shortly. The following places were visited by me:—

Pattambi: Agricultural Research Station for the West Coast. Rice investigations of chief interest.

Mangalore: Rice, sugar-cane; cashew.

Ullal: Coconut; casuarina.

Surkatal: Coconut, sugar-cane.

Mudrabidri: Rice.

Kasaragod: Experimental Coconut Station, rice.

Nileshawar: Experimental Coconut Station, tobacco; rice.

Chavrottur: Experimental Coconut Station.

Taliparamba: Pepper Experimental Station.

Tellicherry: Rice in saline lands.

May 29 to June 6—Coimbatore; General observations. I attended an Agricultural Show at Tirrupur and a Horticultural Show at Cotacamund.

June 7 to 12—I visited the Godavari delta on the East Coast. Maruteru: Agricultural Research Station for this area. Rice is the chief crop but the cultivation of other annuals in delta land is being studied. I visited rice mills in the neighbourhood and studied the irrigation system.

June 13 to 17—Coimbatore: General observations, but particular attention paid to irrigation and tillage; rice; millets.

June 18 to 30—Returned to the West Coast where the South-west monsoon had set in. The upland farms had been sown, rice nurseries were being made, and in a few areas transplanting had commenced. The chief places visited by me were as follows:—

Pattambi.
Mangalore.
Buntwal.
Beltangadi.
Mudabidri
Karkal.
Udipi.
Tellicherry.

July 1 to 10—Coimbatore. The South-west monsoon was now causing occasional showers, irrigation water was available, and on the Paddy Station I witnessed ploughing, green manuring, and the sowing of wet nurseries. The general work on the farm was of great interest, and I observed the preparation of the land for all the important crops. I visited Kangayam, famous for its cattle.

July 11 to 19—I visited the Tanjore delta with the Paddy Specialist Aduturai. Here is the Agricultural Research Station for the Tanjore delta. The rainy season had not begun but irrigation water being available, I was able to see the preparation of the fields, rice in nurseries, and, in a few cases, rice being transplanted. Rice is the main crop on the Research Station but the question of growing other crops—such as sugar-cane, banana, ground-nut and benniseed—in the delta land is being carefully studied. I visited several rice mills and made a tour of the rice lands near Mayavaram and at Tranquebar on the coast.

July 20 to 21—Madura.

July 22—Colombo.

July 23 to 26—Peradeniya. Paddy Station, Agricultural Station and Botanic Gardens. I visited rice farms in the neighbourhood; in many cases the "Yala" crop was almost ready for harvesting. I made a brief visit to Polonnuruwa to meet Mr. Lord who was formerly the Economic Botanist.

July 27 to 28—Colombo.

July 29—Sailed from Colombo.

II—RICE CULTIVATION IN SALINE LANDS.

SALINE LANDS IN SIERRA LEONE.

A large proportion of the delta lands in Sierra Leone is subject to tidal flooding. In the dry season, when the rivers are low, salt water extends far up the rivers and creeks, and the marginal lands become so saline that at this time rice cultivation is rendered impossible. In the rainy season, however, the volume of river water is very great and fresh water conditions exist even in the estuaries.

2. Throughout the delta lands, salinity is a limiting factor in the cultivation of rice. In the estuarine lands, where fresh-water conditions exist for only two to five months, rice can be grown only with difficulty if at all; higher up the rivers where fresh conditions persist for five to ten months it is possible to grow rice without any difficulty, although it is seldom possible to grow more than a single crop in one year.

3. At present there is a little incentive to development of the very saline lands, but with an increased population and an assured market for any surplus crop it seems highly probable that an attempt will be made to bring these areas under cultivation.

SALINE LANDS IN INDIA.

4. In India such lands are generally used for rice and when I was there I had an opportunity of noting the methods employed. At present some of these methods are not applicable to Sierra Leone conditions but they are of interest since they are indicative of the lines along which development may be attempted.

5. I visited the Godavari and Tanjore deltas on the East Coast, but climatic conditions there are not similar to those found in Sierra Leone and there are only very limited areas subject to tidal flooding. At Tranquebar in the Tanjore delta there is a small area of marginal land which is liable to inundation by salt water at high tides and which would be ordinarily too saline for rice. Rice cultivation has been made possible by making a strong earth bund on the edge of the creek. The rainfall is low but by the liberal use of water from the delta irrigation system it is possible to keep the land sufficiently fresh.

6. In Malabar on the West Coast there are many areas, of deltaic origin, similar to the saline lands in Sierra Leone. These areas are reclaimed mangrove forest lands; they are subject to tidal flooding and would be ordinarily too saline for rice, but by the judicious use of bunds and specialized cultural methods it is possible to grow certain varieties. Typical examples of this "Kaipad" cultivation, as it is called, were studied at Tellicherry, and the following description is based on my personal observations supplemented by information gained from local farmers and Agricultural Officers.

7. Tellicherry is on the coast and the areas described are the low-lying marginal lands of the creeks and small rivers which enter the sea near the town. The rainfall and climate are very similar in every way to those found in the Sierra Leone deltas. During the height of the rainy season—June to September—the river water is fresh but in the dry season salt water enters the rivers and creeks and, at high tide, floods the marginal lands.

8. Where "Kaipad" cultivation is practised the salt water is kept out by making a strong earth bund between the river and the farm lands. These bunds are tedious to make as they must be very strongly constructed; they are usually about eight feet wide and about four feet higher than the top of the river bank. Flooding and irrigation are controlled by means of sluices, which consist of long narrow wooden box-like constructions which are placed low down in the bunds. Each end of the sluice projects and can be closed by dropping a sliding door. The land lying between the large marginal bund and the uplands is divided, by smaller bunds, into areas of $1/10$ to $1/5$ acre; some of these bunds mark the boundaries of individual farms but their chief purpose is to facilitate water control.

9. The rice crop is harvested in November at the end of the South-west monsoon. If the water in the river is not too brackish it may be admitted within the bunded area and allowed to remain there until the following January. Prawns and small fish thrive under such conditions and form a subsidiary source of income to the owners of these lands.

10. Early in the year, generally in February, the fields are drained until the surface soil is dry but not hard. Then using a short-handled hoe, with a blade about nine inches wide and six inches in depth, the farmer heaps the land into circular mounds two to three feet in diameter and a little more than one foot in height. The soil is cut out in chips or small blocks which are heaped loosely so that the salt may be more easily washed out when the rains begin; before making a mound the spot on which it is to be placed is turned over.

11. As long as there is salt in the river great care is taken to prevent any flooding from that source; the sluices are seldom opened and then only at low tide. At the end of May, the South-west monsoon commences and water starts to collect within the bunded areas. When the fields have been well flooded with rain water the sluices are opened at a period of low tide and all standing water is drained off. The sluices are then closed and the fields flooded again. This process is repeated until the salt has been sufficiently removed. When the rains become very heavy in June it may no longer be possible to drain the fields thoroughly as the river may be in flood. However, it will be feasible to drain off most of the standing water and this is done when it is time to sow or transplant.

12. Sowing takes place in June, by which time the mounds have weathered considerably. The tops of the mounds are levelled, any large lumps of soil being broken up during the process. Germinated seed is now sown on the levelled mounds the tops of which should be just clear of any water in the fields. Three days after sowing water is admitted from the river, which is now fresh, and permitted to cover the seed to a depth of four to six inches. After two to three days the fields are drained, water being again admitted three days later, although this time it is not allowed to overtop the young seedlings. After a further three days this water is drained off and for a period of about 25 days no irrigation from the river is carried out, there is however a considerable accumulation of rain water. At the end of this period the fields are drained, weeding is done if necessary, and transplanting is begun.

13. The method of transplanting is as follows: Using a wide short-bladed hoe the transplanter chips off pieces from the mound in such a way that each chip has four or five seedlings growing on it. These chips are spread contiguously over the field and when transplanting has been completed the field should be at its original level and the rice plants should be in small clumps separated from each other by about six inches. At the time of transplanting the mounds will be found to have subsided greatly and after all the seedlings have been chipped off only a slight prominence will mark the position of each mound; before proceeding to the next mound the remains of the first mound are levelled and any surplus is spread in the space between it and the next mound.

14. Transplanting completed, the fields are flooded for about three days, the level of the water being kept at about half the height of the rice. Subsequently, if the water in the river is fresh, the sluices may be kept open and water allowed to go in and out with the tides. If the river water is brackish the standing water in the fields is occasionally allowed to drain into the river at low tides; the sluices then being closed once more and the fields replenished by direct rainfall, augmented by the "run-off" from the adjacent uplands.

15. Harvesting begins in late October or early November and the fields are drained dry shortly before operations begin. Only the panicles are harvested, the straw being left to provide manure and to improve the physical condition of the soil.

16. The rice grown in these bunded areas is usually the variety known as "Bali." This rice withstands a considerable amount of salinity but it has rather a weak straw and lodges easily if not protected from floods; for this reason it is rarely grown outside the bunded areas. "Bali" is an awned rice of five months duration. There is another variety, known as "Orkayama" which can withstand rougher conditions and an equal if not greater degree of salinity. "Orkayama" also is a five months rice with a red pericarp but it is awnless.

17. "Orkayama" is sometimes grown on lands which are unbunded but otherwise similar to those I have been describing. In such lands the procedure is as follows: In May seed of "Orkayama" is sown in dry nurseries. When the seedlings are about forty days old they are transplanted on the top of newly-made mounds; these mounds are slightly larger and more compact than those made inside the bunded areas. I should mention that the seedlings are topped before being transplanted; they are transplanted two to four seedlings together, in bunches separated by about five inches from each other. The rice remains on the mounds for about twenty-five days, after which it is transplanted for a second and final time. The methods of transplanting and of subsequent treatment are the same as those described in paragraphs 13 and 14.

SUMMARY OF INDIAN METHODS.

18. The methods employed in the cultivation of rice in saline lands on the Malabar Coast may be summarized under three main heads:—

- (a) The use of large bunds to keep out salt water.
- (b) Cultural and irrigation operations to effect the removal of salt already in the soil. The removal of excessive salinity is effected chiefly by alternately flooding and draining the fields, the process being facilitated by heaping the land into loose mounds before the rains begin. The heavy rains of the South-west

monsoon remove the salt in heaped soil. Flooding is due chiefly to direct rainfall, but if there is high ground adjacent the "run-off" from it is also contributory and is utilized with advantage. All the salt is not removed from the soil and during the dry months a deposit can be seen on the surface; but the "washing" operations which I have mentioned as taking place in the rainy season remove sufficient salt from the surface soil, and the water standing in the fields during the growth of the crop prevents any harmful rise of the salt in the sub-soil.

- (c) The use of salt-resisting varieties. No rice will thrive under very saline conditions but certain varieties can tolerate considerably more than others: "Bali" and "Orkayama" are such varieties.

APPLICATION OF INDIAN METHODS TO SIERRA LEONE CONDITIONS.

19. The methods described could be successfully practised in the saline lands of Sierra Leone if the rice farmers were prepared to take sufficient pains; I am sure that not many of them are prepared to do so at present, as, generally speaking, there is as yet insufficient economic pressure to make it profitable for the people to work very saline areas when substantial earth bunds are a necessity. In time the system may be adopted in its entirety, and, when this takes place, a large area which would otherwise have remained untouched will be made available for rice cultivation. Modifications of the system can however be usefully practised now, and I put forward some suggestions for consideration.

20. The Sierra Leone delta lands may be divided into three classes, each subject to be a different degree of salinity.

- (i) *Main Rice Areas*.—In the main rice areas which lie along the rivers just above their estuaries, salinity does not worry the farmer very much; fresh water is plentiful for about nine months of the year—from May to February—and there is no difficulty about raising a good crop of rice. Salinity may be considerable for a short period in the dry season but when the wet weather returns the salt is soon washed out of the surface soil. In many cases the farmer regards this temporary salinity as a blessing as it saves him much labour by killing off most of the weeds on his farm. Double-cropping is practised in the most favourable parts of these areas; by using a salt resisting variety of rice it should be possible to extend the area now used for this purpose. Bunding, to keep out salt water, is not necessary at present as it would not lengthen the growing season since at present the only source of water during the dry season is the tidal overflow.
- (ii) *Estuarine Areas*.—In the mangrove swamps that border the estuaries and the creeks that ramify from them, fresh-water conditions are of comparatively short duration and exist for only two to five months according to the proximity of the area to the sea and the volume of fresh water from the rivers.
- (a) In Sierra Leone when fresh conditions persist for four to five months it is the practice to grow a quick maturing rice. The seedlings are raised in dry nurseries and transplanted as soon as the land is sufficiently free from salt. As a rule sowing takes place in June and transplanting at the end of July; the crop is harvested in November just before salinity becomes pronounced. The land is not cultivated in any way; very little weeding is done—nor is it required—and bunds are not made. The use of this type of land for rice is of recent occurrence and its practice is chiefly confined to the delta lands, of the great Scarcies river, below Balansera in the Samu Chiefdom. There are similar areas in the estuaries of all the Sierra Leone rivers and steady, if slow, development is anticipated. Expansion may be hastened by supplying seed of short-duration rices such as Pa D.C. and Pa Yenti.

The quick-maturing rices, "Adt. 3" and "Wateribune," and the salt resisting varieties, "Bali" and "Orkayama," may all prove useful in these areas and they should be tested for suitability. Bunds to keep out salt water would be beneficial but they are not an economic proposition at the moment. Good drainage is necessary in these areas as it is essential that the salt should be washed out of the surface as early as possible after the rains begin. As a general rule there is fairly good drainage, as the marginal lands are well served by numerous small creeks that ramify from the rivers, but in a few places additional drainage would be advantageous. Good results may also be obtained by digging in the rice stubble and by heaping the land during the dry season. There is no necessity to sow the seed on the heaps and I recommend that the seedlings be raised in the usual dry nurseries and transplanted in the ordinary manner, the heaps being levelled just previous to the transplanting operations. It is interesting to note that in the Port Loko creek there are many farmers, who, for some years, have been heaping the land during the dry season. The system was adopted to combat

Paspalum vagination which is a very troublesome weed on many rice farms; it was found that the adoption of this method not only assisted in clearing the land of weeds but greatly increased its fertility. I believe that the greatest benefit derived from this system is the washing out of saline accumulations in the surface soil.

- (b) There are considerable areas on the sea board, and along the creeks near it, where fresh-water conditions exist for only two to three months and I am of the opinion that bunds are a necessity, if rice is to be grown here. Any extensive development of these areas cannot be expected in the near future as there will not be much incentive to work these lands until the ordinary delta land is more fully exploited. When developing these coastal lands it must be remembered that it is important, as the Director of Agriculture has pointed out, to leave mangrove belts to protect the marginal lands from erosion. Near several villages in the Port Lork District attempts have been made to grow rice in these very saline areas but so far no success has attended these efforts, and I believe that no other result can be obtained until a modification of the Malabar system is adopted. Fresh-water conditions are of such short duration that it will be necessary to use bunds to keep out salt water at high tide. At the moment the farmer in this country is not prepared to make any elaborate bunds, and, this being so, I suggest that a start be made with a small trial on a piece of saline swamp adjacent to higher land and with good facilities for drainage. If a piece of land is selected near the edge of any swamp close to the sea it will be necessary to make a very large bund as the tidal rise will be so great; but if a piece of land adjoining the higher land is chosen quite a small bund will be sufficient to keep out the tidal salt water; the bunded area can be kept fresh by using the run-off from the higher land to supplement the direct rainfall. One or two simple sluices will be required in the bund for drainage and irrigation. Except during the brief period of fresh-water conditions, it will be imperative to keep the sluices closed except at low tide. Within the bunded area the method of work should be as described in paragraph 20 (ii) (a).

- (iii) *Saline Sedge Swamp*.—In parts of the delta land extensive sedge swamps are found behind the mangrove forest lands. The soil in the swamps is rich but rice can rarely be grown with success. Deep flooding is sometimes troublesome but the chief limiting factor is soil alkalinity, due to insufficient drainage. These lands become very swampy in the rainy season but dry up in the dry season. They are subject to tidal flooding during periods of high tides and in the dry season salt water reaches them; as drainage is poor some salt water remains behind and either evaporates or soaks into the soil, with the result that the latter becomes very saline. Some of the salt is washed away during the rainy season, but until the areas are properly drained they will always be too alkaline to be satisfactory for rice cultivation. At present the development of these areas seems unlikely although it may not be long until it will be an economic proposition. To make these swamps available for rice, drainage is the first essential; bunds to prevent the ingress of salt water will be an advantage although not always a necessity; and the use of salt resisting rices and specialised cultural methods—mentioned in paragraph 20—will be beneficial.

21. *Salt-resisting Rices*.—I obtained two salt-resisting rices—Bali and Kultooth—from Malabar, and one—Ovar-karrupan—from Ceylon. I have requisitioned for “Orkayama” from Malabar. When I refer to rices as being salt-resisting I do not mean to imply that they can thrive under very salty conditions; for the sake of convenience in reference I have given this name to varieties which are known to tolerate a degree of salinity which would be detrimental to ordinary rices.

III—THE TECHNIQUE OF PURE LINE SELECTION.

This appendix is an attempt to describe the technique of pure line selection as practised on the Government Paddy Breeding Stations in Madras and Ceylon. Reference is made to some details of farm and nursery management. As my visit was of such short duration I was not able to see all the various steps of paddy breeding; and for much of the matter in this account I am indebted to information supplied verbally and in the form of notes by the Paddy Specialist (Mr. K. Ramiah) and his staff, particularly Mr. Jobitharaj, in Madras; and to the Economic Botanist (Mr. J. C. Haigh) and his staff in Ceylon.

MADRAS.

2. The farmer's rice crop is often a mechanical mixture of different varieties and, invariably, a genetic mixture of different strains. The object of the rice breeder is to isolate the best strain in the genetic mixture, and this is effected by carrying out single plant cultures. In Madras a strain is considered to be an improvement if, without preferential treatment, it gives a yield of not less than 10 per cent. more than the farmer's crop from unselected seed. The following is an outline of pure line selection as practised on the Central Paddy Breeding Station at Coimbatore.

3. *Preliminary.*—The area for which improved seed is required is visited by a competent officer who studies all the important varieties and decides which can be most profitably improved. If it is decided that a variety can be improved, small samples of seed—1 lb. is a suitable quantity—are collected from a large number of farms scattered through the tract in which the variety is grown. Each sample is suitably labelled. On return to headquarters all the samples are bulked, and a representative sample of the required quantity is set aside for selection.

4. *First Year.*—The farmer's bulk sample is sown in a nursery, and duly transplanted, in a one-tenth acre plot (six inches apart). The crop, which is a mixture of varying types, is kept under constant observation and, when it has passed the milk stage, promising plants with the desired qualities are selected; the more selections the better, but 100–150 is a good number. In selecting these plants from the bulk crop, particular attention is paid to the following points: duration, height, tillering, uniform heading and well-filled grains and freedom from disease.

5. Each plant selected is immediately labelled with a strip of herbarium mill-board bearing the varietal name and the appropriate sequence number. Selfing of these single plants is not considered necessary. When ripe, the ear heads from each selected plant are collected and placed in muslin bags which are labelled both inside and outside. The paddy is dried without removal from the bags; it is then stripped by hand, and placed in wide-mouthed screw-top bottles containing a ball of naphthalene and the label from the inside of the muslin bag.

6. *Second Year.*—In the second year the single family, or observation, plot stage is reached. About 2 ozs. of seed of each of the selected single plants is sown in seed beds which may be conveniently 3 feet broad by 4 feet long with a 2 feet channel around as well as between the individual beds.

7. When ready, the seedlings of each strain are planted in a strip which is usually 50 feet long and 5 feet wide. The plants are spaced, singly, six inches apart. An alley, 2 feet wide, is left between each strip and its neighbours.

8. These single family plots are kept under constant observation, and any abnormal behaviour is noted. Flowering records are kept as a uniform rate of flowering, is an indication of purity, and hybrids detected by this method are rejected. Pigmentation is noted and plots containing plants exhibiting splitting for this character are eliminated. After flowering, 100 plants in each of the unrejected plots are subjected to tiller counts and height measurements. The grain from the selected 100 plants, none of which are taken from the border rows, is harvested; and after drying is stripped, weighed and, finally, after the grain has been tested for evenness, stored in kerosene tins: the zinc plot label is put inside the tin and a tag label tied on outside. Of the strains which have not been rejected for impurity on any of the counts mentioned above, 40 to 50 of the best yielders are retained for further trial in the following season.

9. *Third Year.*—The selections carried forward from the second year are now admitted to comparative yield trials. The standard of comparison is the farmer's bulk crop which has been mentioned in paragraphs 3 and 4; for control purposes some of this seed is propagated without selection from year to year.

10. About 25 ozs. of seed of each strain is sown in a long seed bed, the usual dimensions of which are 5 feet by 40 feet. The plots in which the seedlings are subsequently transplanted in singles 6 inches apart, are 40 feet by 4 in size, and have 1 foot alleys around and between them. A border, 5 feet to 10 feet wide, is left around all the plots and is planted up as a bulk with seedlings from the control nursery. The strips are replicated at least six times. Recently the lay-out has been in the form of randomised blocks but the Latin square arrangement may be adopted when the number of varieties under trial is suitable. The yields of the different strains are carefully studied and those giving significantly higher yields are carried forward for further trial.

11. *Fourth Year*.—The strains carried forward for the third year are submitted to further comparative trials. These trials may last for one to three years, if necessary; but eventually, a single strain is left, and this, if it is still satisfactory, is given a station number and released for district trial.

12. *District Trial*.—When a strain has survived the eliminating tests at the Paddy Station its seed, from the multiplication plot, is submitted to a district trial which is carried out in a field belonging to a farmer in the district from which the original seed was obtained. The lay-out of the field is usually the A.B.B.A. strip arrangement; strips of one-fortieth acre, replicated eight times, are considered satisfactory. At harvesting, the two outer strips are rejected; the yields from the remainder are recorded, and the significance in comparison with the control is determined. If the strain is an improvement, seed is given to the District Agricultural Officer for general distribution. It should be noted that the seed supplied to the District Agricultural Officer is obtained from the multiplication plot on the Paddy Breeding Station, and not from the district trial plots.

13. *Multiplication of Strains*.—For the maintenance of purity, without recourse to bagging, seed, of each strain undergoing comparative trial, is sown separately in special multiplication plots. For example: in the third year of pure line selections, when single family strains are first subjected to comparative yield trials, duplicate sowings of all strains are done. For this purpose 4 ozs. of seed are used and the seedlings are eventually planted out in ten lines for each strain. In the fourth year, comparative yield plots, as well as a further seed multiplication plot, are sown with seed from this plot (the outer rows of which are of course rejected before harvest) as it is unsafe to use seed from comparative trial strips for further trials as there will have been some crossing. These seed multiplication plots are maintained from year to year as long as the strain remains unrejected.

14. *Nursery Work*.—The seed beds are prepared with the greatest care, since for experimental work it is essential that the seedlings should be uniform in every way. The first ploughing is done with an iron plough, immediately after the first irrigation of the land. The fields are subsequently kept wet and receive two ploughings with the country plough. The nursery receives a heavy dose of green manure, as much as 10,000 lb. per acre, which is trampled into the puddle. The individual beds are prepared some three weeks later. The fields are levelled, first with the large bullock-drawn leveller and secondly with the hand leveller. The seed beds are then marked out with coir rope. Each bed is surrounded by a small temporary bund, in the making of which great care must be taken to use only mud from the channels separating the different beds. The individual beds are now levelled by hand, and water to depth of about 1 inch is left standing in each.

15. A nursery plan and a sowing programme are always prepared, and the different sowings are carried out strictly in accordance with the schedule. Three days before sowing, steps are taken to germinate the seed. With small samples stored in glass bottles all that is required to be done is to pour water into the bottle and allow the seed to soak overnight. On the following day the water is drained off by inverting the bottle over a wire mesh: the seed is rammed down tightly and, together with other bottles similarly treated, is placed on a tray, which having been covered with a wet gunny bag, is left in a dark room until the next morning, when it will be found that all the seeds have germinated and are ready for sowing.

16. On the next day the bottles containing the sprouted seeds are arranged on the bunds of the nursery beds which have been previously labelled according to the nursery plan: the labels, which are zinc inscribed with black Japan paint, are tied to stakes placed on the left hand corner of each bed. Seed should not be sown within two or three inches of the bund, and, if possible, it is beneficial to have a layer of about 1 inch of clear water in the bed when sowing is being done. If weather conditions are good the beds may be drained immediately after sowing, but, if there is rain, drainage should be postponed until it is over, as heavy rain may spoil uniformity of conditions by washing the seed and soil. It is desirable that the beds should be drained as soon as possible after they are sown, and left dry until the surface soil begins to crack: at this stage water is admitted for a few hours and again drained off; this process may be repeated but after a week from the date of sowing a constant supply of water should be maintained. The seedlings are left in the nursery for thirty to forty days according to the variety: short duration varieties requiring a shorter time in the nursery than do the slow maturing varieties.

17. At transplanting time the nurseries are well flooded to facilitate the removal of the seedlings. The uprooting and bundling of the seedlings necessitates great care, as mixing must be avoided at all costs, and the women who do the work are therefore placed in alternate beds. The seedlings are pulled one by one, and, when sufficient have been obtained to make a conveniently sized bundle, they are tied together and all soil washed from the roots. It should be noted that the border seedlings are not used as they are often extra vigorous. When all the seedlings have been pulled up and treated as described, the bundles are securely tied to the labelled stake, which is now transferred from the corner to the centre of the nursery bed.

18. *Farm Work.*—The preparation of the farm plots is commenced as soon as the nurseries have been sown. The preliminary cultural operations are similar to those carried out in the nursery with the exception that manuring is not so heavy; 4,000 lb. of green leaf or 300 lb. of castor cake is considered sufficient. From the date of initial flooding it is desirable that the field should be in a constant state of puddle.

19. A planting programme and plan are always prepared. The following description refers to the planting of the five foot wide single family plots but the principle is the same in all cases. The strips are demarcated with pegs and coir rope; and, after being labelled according to the planting plan, the seedlings from the seed bed with a similar number are brought and placed at the head of each strip.

20. To facilitate planting the women who do the work are provided with marked bamboo sticks. Each woman has three sticks: two five foot sticks marked at 6 inches intervals and one four foot stick similarly marked. The five foot sticks are laid, one on each side along the ropes forming the long sides of the plot; and the four foot stick is laid across the plot with its ends just touching corresponding marks on both side sticks. A seedling is planted at each mark on the cross stick which is moved back, 6 inches at a time, as the woman, walking backwards, works her way down the plot. When a distance of 5 feet has been planted the side sticks are taken up and relaid. This method of planting can be used for plots of any size by first dividing the area into narrow parallel strips: cross check ropes should be laid at distances 10 feet apart.

21. During planting operations only a thin layer of water is left in the plot as a greater depth would make the manipulation of the sticks difficult. This water soon evaporates or drains away, and on the third day after transplanting it is generally necessary to admit a gentle flow of water. This water too is allowed to diminish but is renewed after a few days. Ten days after transplanting, the seedlings may be said to be established; and at this stage the yellow colour which the plants have exhibited since they were transplanted is replaced by a healthy green colour. More water is now admitted and, until shortly before harvesting, is maintained at a depth of about 4 inches.

22. *Testing Single Family Selections for Purity.*—The single family plots are all submitted to very careful purity tests, of which the chief are: flowering duration, uniformity of height, evenness of grain, and tillering.

23. *Flowering.*—A plant is recorded as having flowered as soon as the first ear head appears on a main tiller; and a strip is recorded as having flowered when more than 75 per cent. of the individual plants have flowered. Pure line cultures should complete flowering within a week. In testing for flowering duration it is necessary to record the flowering date of each plant, and this is accomplished in the following manner: a plan of the plot is made on squared paper on which each plant is represented by a square. As each plant flowers the date of the occurrence is recorded in the appropriate square on the plan; if flowering extends over portions of two months the dates referring to the latter month should be prefixed with a distinguishing letter. The recording is done by two people: one, armed with a stick 6 feet long, walks down the alleys between the strips and calls out the numbers of all plants in flower; the other sits on the bund at the end of the strip and enters the information on the flowering chart. Flower marking is done on alternate days. From the chart records a graph is plotted: if the graph is unimodal the strain is properly pure but if it is polymodal a genetic mixture is indicated and the plot is at once rejected.

24. *Height.*—Measurements are made after the ear heads have fully emerged, and are taken to the top of the highest panicle. Measurements are recorded for 100 plants.

25. *Evenness of Grain.*—One hundred plants are harvested separately and the ear heads placed in numbered paper bags. In due course 50 to 100 grains are taken from each bag and carefully measured with a vernier calipers for length, width and thickness. These measurements are summed and if the strain is pure the difference from the arithmetic mean should not be more than two or three.

CEYLON.

26. The method of pure line selection is different from that employed in Madras as the following outline of the technique used at the Peredeniya Paddy Station will show.

27. *Preliminary*.—From a field of the variety under selection fifty ear heads are selected, partly at random and partly for visible desirable qualities.

28. *First Year*.—The seed from each ear head is sown in a small seed bed (2 feet by 2 feet) from which the seedlings are in due course transplanted to centgener plots. A centgener plots measures 10 feet by 10 feet, and, as it is planted 1 foot apart, each plot, as its name implies, contains 100 seedlings: there is an outer guard row, so that the over all measurements of the plot are 12 by 12 feet; the forty-four plants in the guard row are discarded at harvest and only the yield of the inner 100 plants is recorded. The twenty best strains are selected on the basis of weight of winnowed grain.

29. *Second Year*.—The twenty strains selected in the first year are tested, in randomised centgener plots, against a control in the form of a crop grown from the original unselected seed. The seedlings are planted, singly, 1 foot apart from each other; the usual guard row is provided. It is considered essential to have not less than six replications in each bunded field. The yields of each replication are summed and expressed as percentages of the control. No increase is considered significant unless it is at least 15 per cent. higher than that of the control; of the strains fulfilling this condition the best two or three are retained for further trial.

30. *Third Year*.—The two or three surviving strains are tested in one-hundredth acre plots with a guard row (over all size of plot one-eightieth acre). The plots are randomised and at least six replications are considered necessary. A final selection, based on yields, is made.

31. *Fourth Year*.—The final selection is returned to the area in which the original ear heads were collected and is there submitted to field trials in which the unselected farmers' seed is used for the control. If it is proved to be still superior, steps are taken to multiply and distribute the seed.

32. *Maintenance of Purity*.—In the fourth year, and in following years if the strain is not rejected, purity is maintained by bagging to prevent cross-fertilization. Each year, single plants are bagged just before flowering. The produce is sown the following year and is labelled S—1. Single plants from this seed are bagged and the produce labelled S—1 for sowing in the third year. The balance of the seed from the S—1 plot is labelled S—2 and is sown as such in the following year. The produce of S—2 is multiplied in the third year as S—3 and the produce of this plot is distributed to the Paddy Seed Stations.

33. The following notes were made on the Paddy Station at Anuradhapura and refer to the methods used in connection with experimental plots on which seed is sown broadcast.

34. The fields are ploughed about three weeks before it is intended to sow the seed: they are flooded for one or two days before ploughing but superfluous water is drained off at the time of the operation. The fields remain drained, but not dry, for four or five days; after which they are fully flooded and maintained in this state for eight or ten days to kill weeds. The fields are then partially drained and while still wet are cross-ploughed. On the following day they are worked with the Burmese harrow and afterwards with the buffalo-drawn level. The silt is now allowed to settle; and, all water having been drained off, the surface of the field is levelled with the hand level. Shallow surface channels are made to drain off any standing water as the latter is said to be harmful to freshly germinated seedlings.

35. The germinated seed is now sown broadcast on the mud where it remains unirrigated for two days, after which time water admitted for half a day and then drained off again. On the third day after sowing, water is left in until it stands just below the tips of the seedlings: this level is maintained for two or three days after which the water is changed every four or five days until the rice is three weeks old. When this stage is reached the fields are drained for a few days as this is believed to encourage tillering. After this the fields are maintained in a flooded condition until the crop shows signs of ripening, as indicated by the colour of the glume commencing to change from green to gold.

36. If transplanting is done the fields should be drained for four or five days after the operation: a light irrigation may then be given and four days later followed by full irrigation. If the irrigation water is maintained at a constant depth of 3 to 4 inches most weed growth will be prevented.

IV—LIST OF PLANTS AND SEEDS BROUGHT OR SENT BACK
FROM INDIA AND CEYLON.

Name.	Origin.	Remarks.
RICE.		INDIA.
G. E. B. 24	Combatore Paddy Breeding Station	Pure line selection. White rice, 149 days from sowing to harvest. Very popular. Excellent table rice.
Co. 5	" "	Pure line selection. White, 164 days.
Co. 6	" "	Pure line selection. White, 157 days.
Adt. 1	Agricultural Research Station, Aduturai	Pure line selection. White, 175 days. A heavy yielding strain, popular in the Tanjore delta.
Adt. 3	" "	Pure line selection. White, 95 days. Valued for its early maturation.
Adt. 5	" "	Pure line selection. White, 185 days.
Jeeragasamba	Coimbatore	Mass selection. Small white rice, 140 days. Not a commercial rice, but a fine variety, very highly valued for local consumption.
Panianala	Pattambi Agricultural Research Station	Red rice, 145 days. Tall rice suited for growing in deeply-flooded lands.
Harisankar	" "	White rice, 145 days. A deep-water variety.
Baitel Fakir	" "	White rice, 140 days. A deep-water variety.
Chenellur	" "	Upland variety, red, 105 days. Can grow under shade.
Bali	Tellicherry	5½ months rice from saline lands.
Kultooch	"	5½ months rice from saline lands.
		CEYLON.
B. 13, Kurulutuduwi	Peredeniya	Pure line selection. 6 months white.
P. 9, Sudunawi	Paddy Breeding Station	Pure line selection. 6 months white.
26639, Kandimurungan	" "	Pure line selection. 3½ months red.
26659, Hetadavi	" "	Pure line selection. 3½ months red.
1. CPY. 15, Suduheenati	" "	Pure line selection. 4½ months red.
28098, Vellai illankalayan	" "	Pure line selection. 4½ months red.
MILLETS.		INDIA.
Eleusine coracana E. C. 47	Coimbatore Millet Station	Pure line selection of different types, of which one at least should do well in Sierra Leone.
" E. C. 620	" "	
" E. C. 1250	" "	
" E. C. 593	" "	
Andropogon sorghun A. S. 809	" "	
" A. S. 1063	" "	100 days.
Setaria Italica S. I. 226	" "	110 "
" S. I. 907	" "	100 "
Panicum miliare	" "	95 "
Panicum miliaceum	" "	100 "
		CEYLON.
Pennisetum typhoideum	Jaffna Agricultural Station	
Eleusine coracana	" "	
Setaria Italica	" "	
GREEN MANURE CROPS.		
Crotolaria juncea	" "	Also a fibre crop.
Dolichos biflorus	" "	Also food and fodder crop.
		INDIA.
Phaseolus trilobus	Coimbatore	Also a fodder crop.
Tephrosia purpurea	"	

LIST OF PLANTS AND SEEDS FROM INDIA AND CEYLON—*contd.*

Name.	Origin.	Remarks.
GREEN MANURE CROPS— <i>continued.</i>		
Phaseolus aconitifolius ...	Coimbatore	Also a pulse crop.
Indigofera endacaphylla ...	"	Good cover.
PULSES.		
CEYLON.		
Phaseolus Mungo ...	Peradeniya	
Vigna ...	"	Long pod variety.
YAM.		
Jaffna King Yam ...	Jaffna	Most prized variety in Ceylon.
SHADE TREES.		
Erythrina lithosperma ...	Peradeniya	
" umbrosa ...	"	
Leucaena glauca ...	"	
Gliricidia maculata ...	"	
ORCHIDS. (Plants)		
Dendrobium nobile ...	"	
" macrostachyum ...	"	
" cruminatum ...	"	
Epidendrum radicans ...	"	
Vanda spathulata ...	"	
FLOWERING TREES. (a) Plants		
Amherstia nobilis ...	"	
Brownea grandiceps ...	"	
" macrophylla ...	"	
Lysidice rhodostegia ...	"	
Tabebuia rosia ...	"	
(b) Seeds.		
Cassia auriculata ...	"	
" grandis ...	"	
" nodosa ...	"	
" Javanica ...	"	
Brownea grandiceps ...	"	
Lysidice rhodostegia ...	"	
Poinciana regia ...	"	Orange blossom.
Parmentiera cerifera ...	"	
Peltophorum ferrugineum ...	Coimbatore India	
FLOWERING SHRUBS (a) Plants		
Clerodendron paniculatum ...	Peradeniya	
Lagerstroemia indica ...	"	
Memecylon umbellatum ...	"	
(b) Seeds.		
Brunfelsia americana ...	"	
Rhodomyrtus tomentosa ...	"	
CREEPERS. (a) Plants.		
Bignonia magnifica ...	"	
Congea tomentosa ...	"	

LIST OF PLANTS AND SEEDS FROM INDIA AND CEYLON—*contd.*

Name.	Origin.	Remarks.
CREEPERS.		
(a) <i>Plants— contd.</i>		
Ipomoea Briggsii ...	Peredeniya	
Thunbergia mysorensis ...	"	
Vitis discolor ...	"	
FOLIAGE PLANTS.		
(a) <i>Plants.</i>		
Agave americana variegata ...	"	
Anomum magnificum ...	"	
Alocasia Sanderiana ...	"	
" cuprea ...	"	
Anthurium Archduke Joseph	"	
" carneum ...	"	

